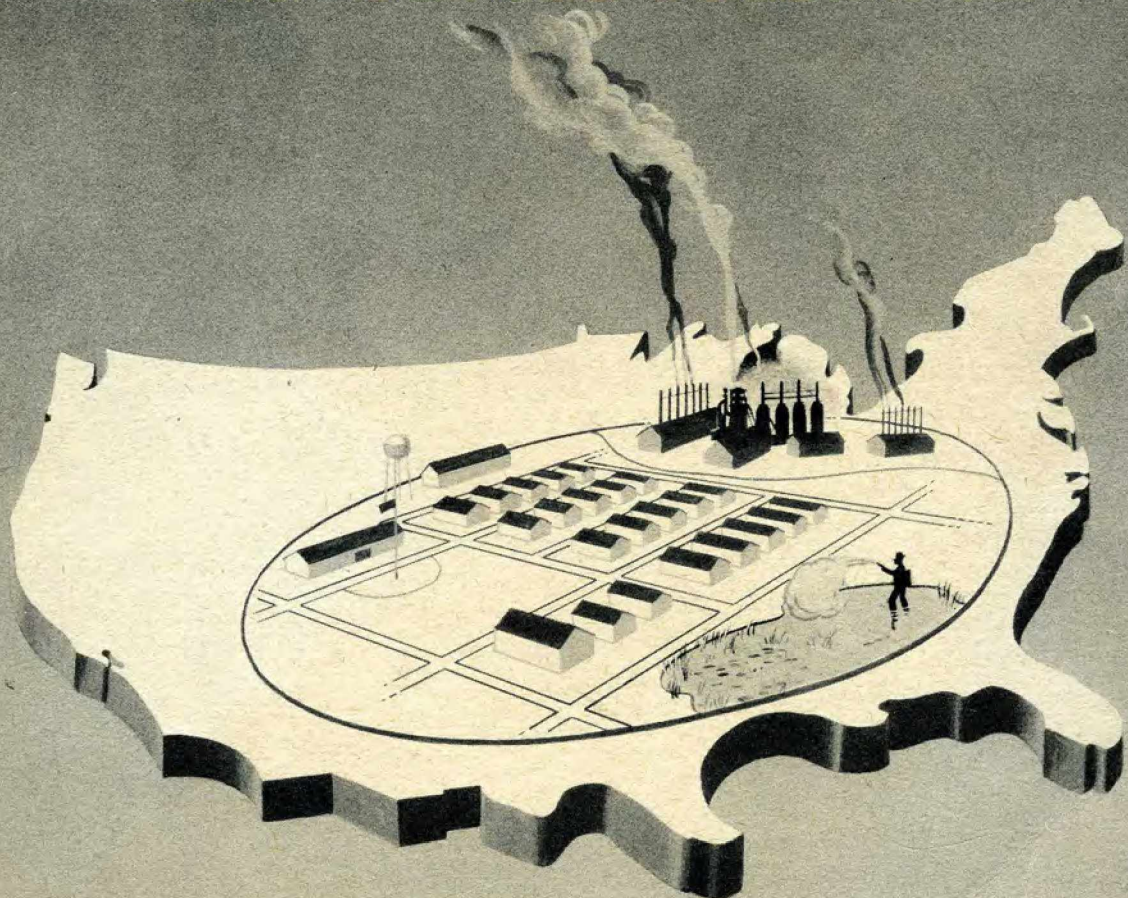
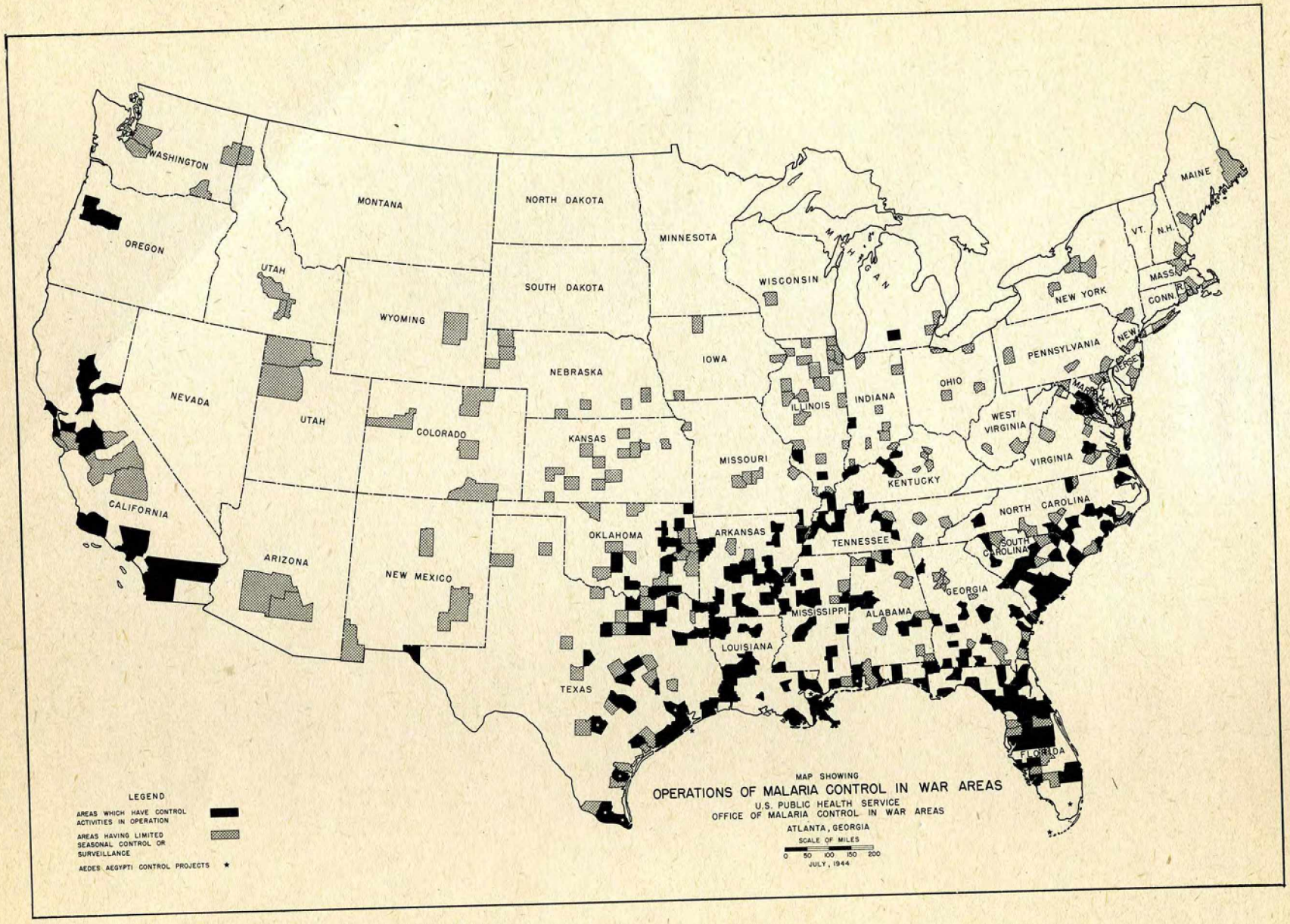
Nora's File

MALARIA CONTROL IN WAR AREAS



1943 - 44

FEDERAL SECURITY AGENCY
U. S. PUBLIC HEALTH SERVICE



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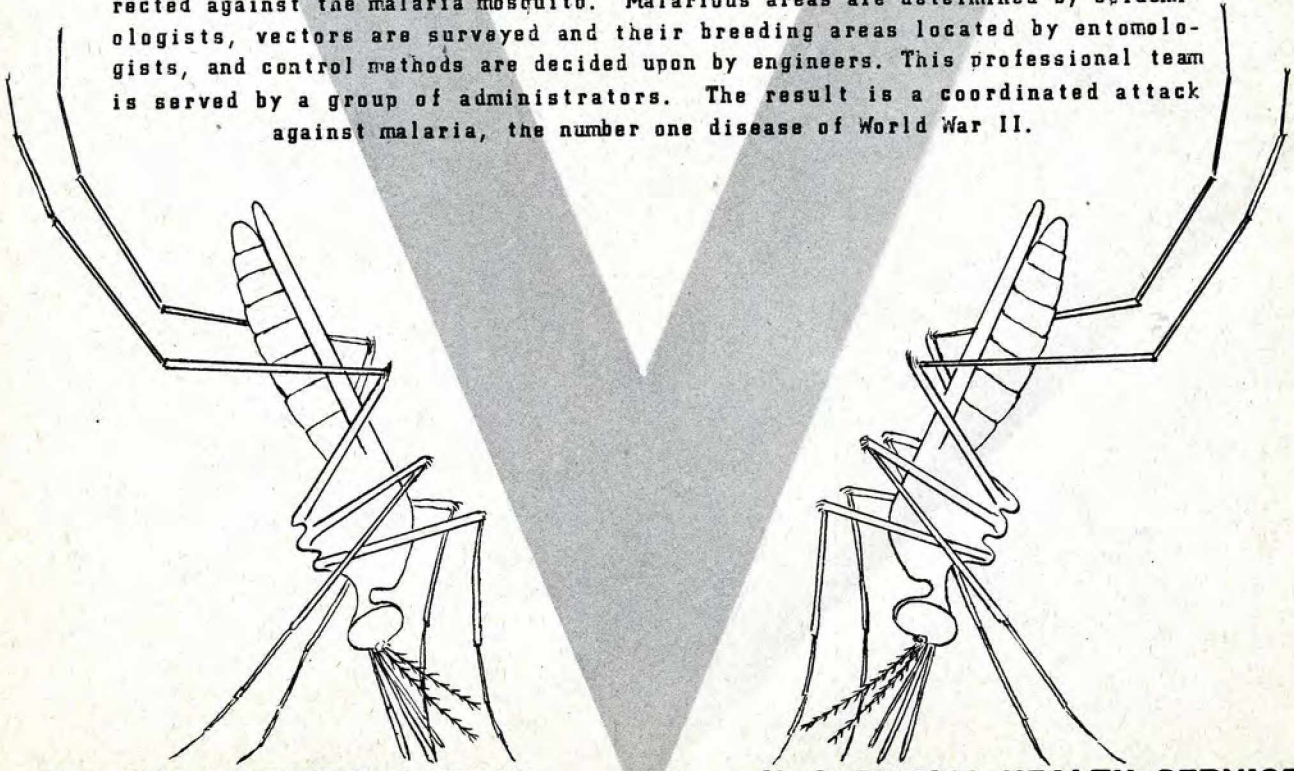
MALARIA CONTROL
IN WAR AREAS
1943 - 44

The Malaria Control in War Areas program, established in March, 1942, is a joint undertaking by the U. S. Public Health Service and State Health Departments designed to reduce the hazard of malaria transmission in extra-cantonment zones of military areas and around essential war industries. It complements similar activities of military authorities within reservation limits. Operations are directed against the malaria mosquito. Malarious areas are determined by epidemiologists, vectors are surveyed and their breeding areas located by entomologists, and control methods are decided upon by engineers. This professional team is served by a group of administrators. The result is a coordinated attack against malaria, the number one disease of World War II.

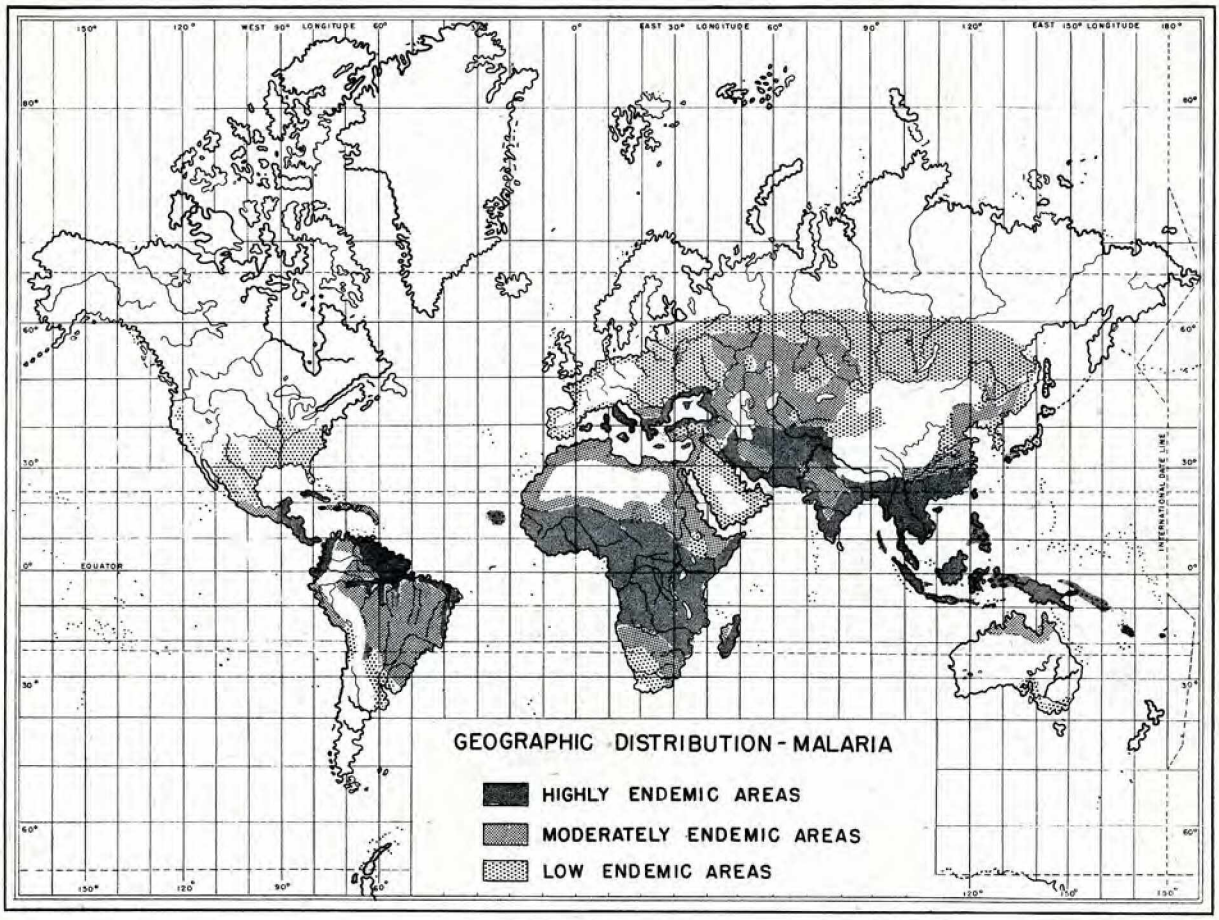


FEDERAL SECURITY AGENCY

U. S. PUBLIC HEALTH SERVICE

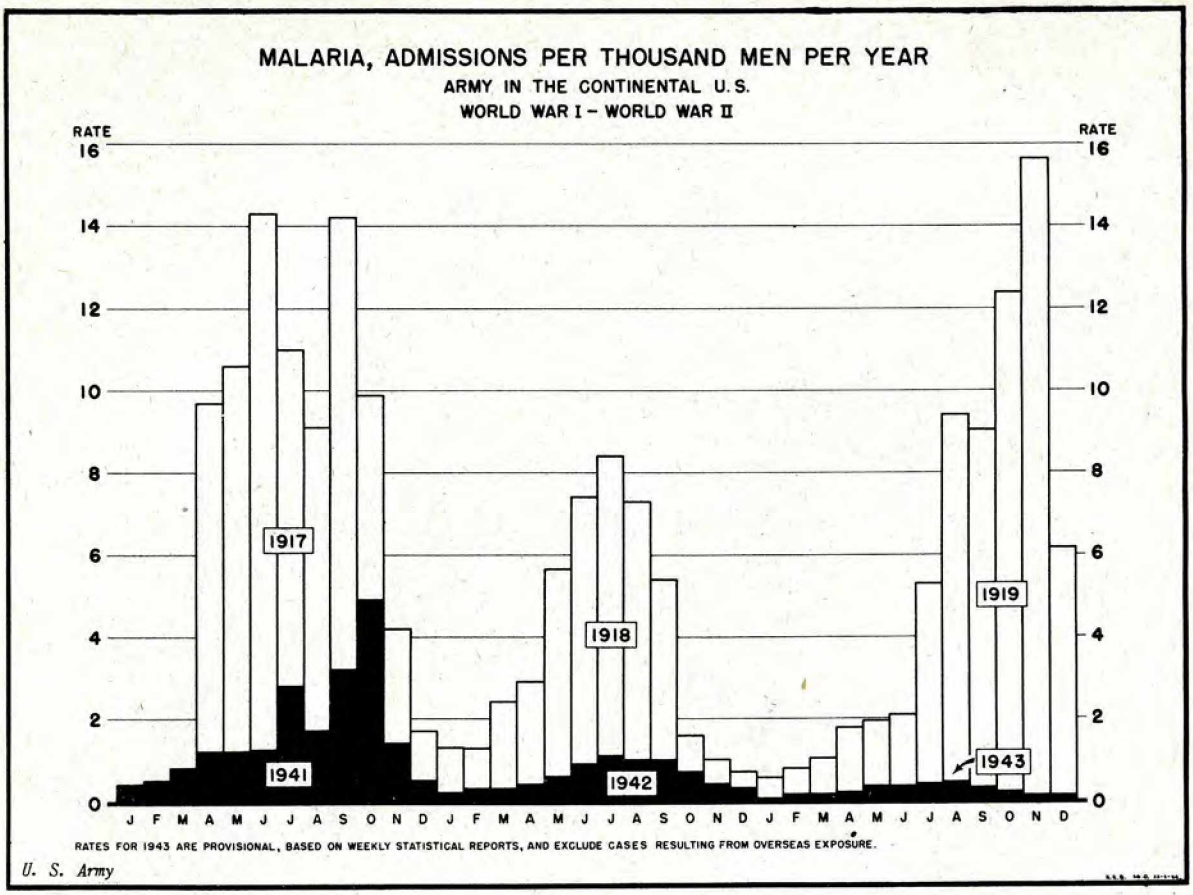
TABLE OF CONTENTS

THE MALARIA PROBLEM



Malaria is no stranger to war. It has plagued the armies of the world from earliest times and has lingered in postwar civilian populations far from its endemic areas. The present war is unique in its world-wide scope. A map of malarious areas of the world shows that the training areas and the battle fronts of World War II coincide with the endemic areas of malaria.

Early in the war emphasis was placed on training. Millions of men were moved from non-malarious areas to the malarious South where the climate would permit year around maneuvers. War industries were expanding rapidly and calling for thousands of migrant workers. America responded to this call in the face of dire predictions from epidemiologists. No mass migration of this kind into a malarious area has ever occurred without serious consequences. That no serious outbreak occurred is probably due to a number of factors, not the least of which were the all-out efforts of Army and Navy sanitarians within military reservations and of the M.C.W.A. program outside the reservations. The record is clear and spectacular; Army malaria admissions per 1000 men in the continental United States were not only a fraction of those for the years of World War I but they actually decreased from 1941 to 1943. During the same period malaria continued its downward trend in the civilian population. It is now at the lowest point in history.



But the malaria battle is not over. We have won the first round but new and unprecedented hazards lie ahead. Men are fighting in spite of malaria in many hyperendemic areas where, without control measures, practically everyone becomes infected. A few of these men have returned home, back to farms and cities, back to every crossroad and corner of the country. As the tide of battle turns it is estimated that perhaps two or more million men will return with foreign malaria parasites in their blood. These will profoundly upset the balance of malaria transmission unless an all-out attack is made to compensate for the overwhelming increase of carriers.

METHODS OF ATTACK

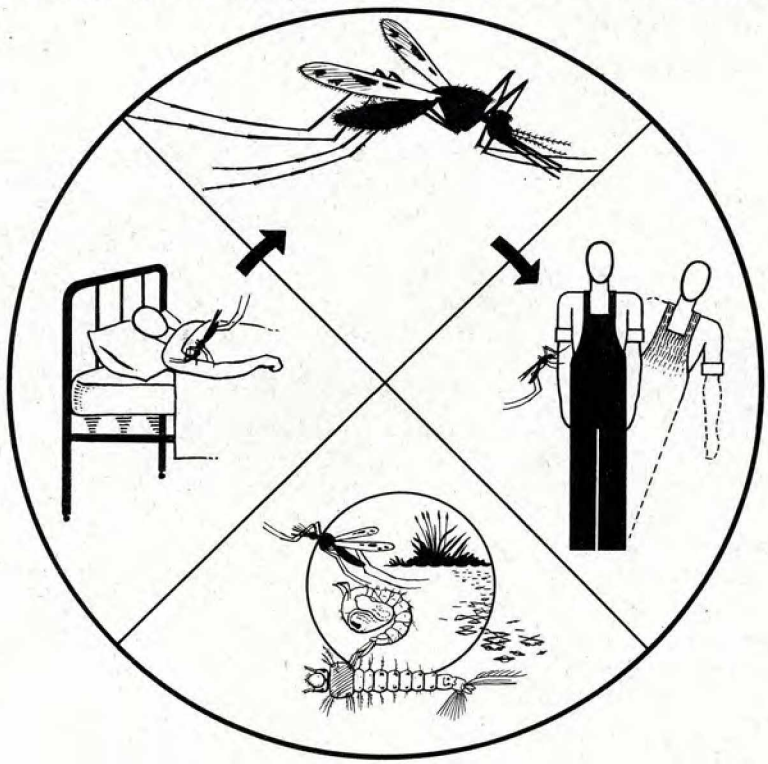
The methods of attacking malaria are few and are for the most part direct. They are aimed at breaking the chain of malaria transmission at one of its weak points. The three links in this chain are a malaria carrier or person sick with the disease, a mosquito vector, and a healthy person. Interwoven in this simple sequence are the life cycle of the malaria parasite and the life cycle of the mosquito. The result is a vicious circle with several vulnerable points. The first segment of the circle is the man sick with malaria. Parasites are circulating in his blood, reproducing, destroying red blood cells and causing chills and fever at regular intervals. Then there is the adult female *Anopheles* mosquito, penetrating into the blood system of the diseased person, sucking sexual forms of the parasite which combine in the mosquito's stomach to produce myriads of new parasites for injection into the third segment of the malaria cycle, a susceptible person. Finally there is the mosquito life cycle, the female laying eggs after her blood meal and thus starting hundreds of new potential vectors on their way.

Anti-malarial drugs. The oldest method

of attack is against the first segment of the circle - the victim of malaria. The art of healing preceded the science of medicine, and cinchona bark was known to relieve the symptoms of malaria long before the parasite or its vector were discovered. Quinine is still one of the best drugs but must be used sparingly since the main sources of supply fell into enemy hands. Fortunately, atabrine, a synthetic drug, is as good or better than quinine but no anti-malarial drug does more than lower the death rate and suppress the more acute symptoms of the disease. The search continues in hundreds of private and State laboratories throughout the world for a drug which is prophylactic and also capable of freeing the patient of malaria parasites.

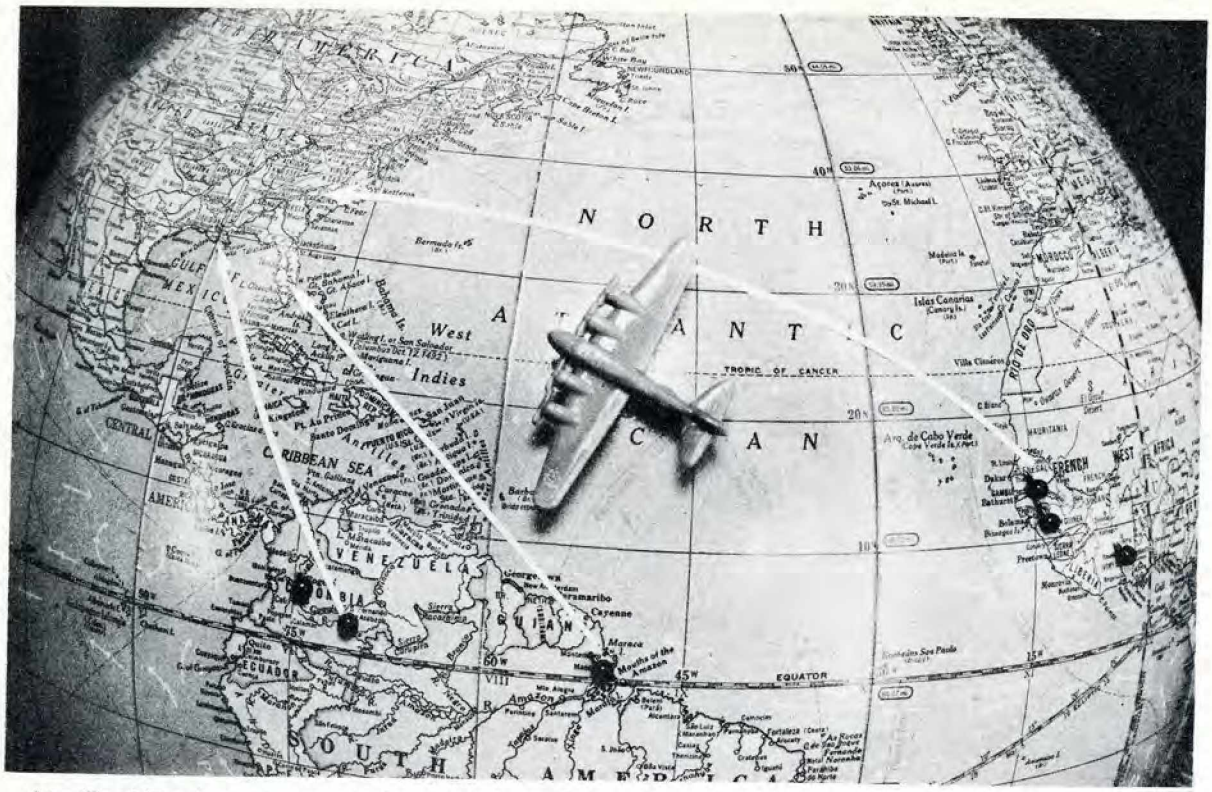
Education. Another vulnerable point for attack is the ignorance of mankind. Malaria is clearly a social disease, inseparably connected with poverty and ignorance. Individual methods of fighting malaria such as mosquito proofing, spraying and the use of repellents mean nothing if the affected populations are not informed of them. Education, then, becomes a positive and far-reaching method of malaria control. People have improved housing and drainage in their communities as they have become increasingly enlightened concerning malaria and its transmission. As civilization has advanced, malaria has completely disappeared from large areas of the world.

Mosquito control. The third point of attack is the mosquito vector. Recent knowledge enables us to concentrate on the objective, save time and money and increase the efficiency of malaria control work. In some instances destruction of adult mosquitoes is particularly effective in malaria control since infected mosquitoes may be killed before they have a chance to spread the disease.



The Cycle of Malaria Transmission

Preventive measures are usually directed at the larval stages of the mosquito in water. Mosquito wrigglers may be killed by poison dusts which are swallowed with their food, or by oil sprays which penetrate their respiratory systems. These agents are effective for only a few days; therefore the regular application of lar-



Air Traffic Increases the Possibility of Introducing Yellow Fever from Existing Foci

vicides is of prime importance in an emergency program. Complete elimination of breeding places by drainage is more permanent and, in the long run, more economical in many places, especially when integrated with other water uses such as conservation programs, flood control and irrigation.

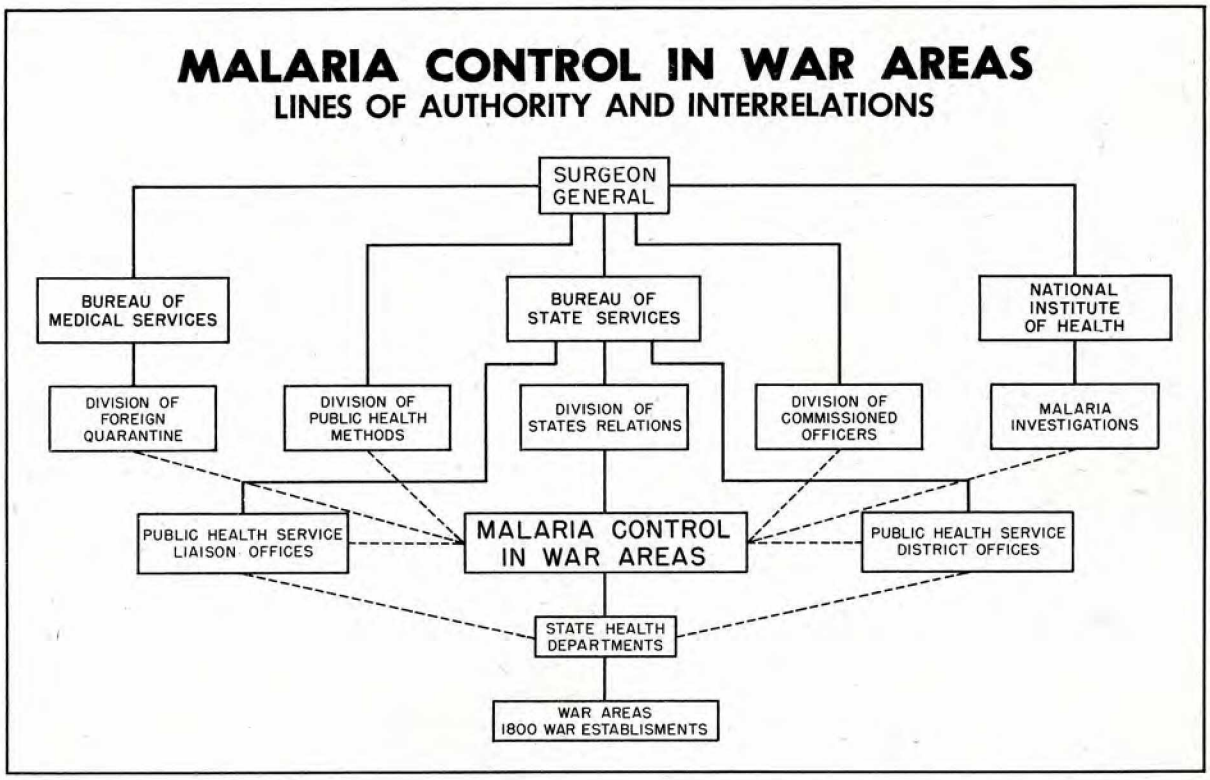
Anti-mosquito measures have been so perfected in recent years that complete eradication has been achieved in the case of two immigrant South American disease vectors. Unfortunately, this is not yet economically feasible for native species, but it has been clearly demonstrated that effective control can be obtained wherever expenditure of the required amount of money is justified. It is not necessary to kill every mosquito vector to control malaria. With a given number of carriers, there is a threshold of sanitary importance below which mosquitoes are so scarce that their chances of becoming infected and transmitting the disease to susceptible people become infinitesimal. If mosquitoes are so few and far between that they do not find malaria patients during their lifetime, the disease will die out.

DENGUE AND YELLOW FEVER

The same basic principles apply to dengue - yellow fever mosquito control. Dengue has already struck in Honolulu and in the South Pacific. It could paralyze any southern city and disrupt war activities if control measures were not carried on. Even more tragic would be the re-introduction of yellow fever. These possibilities are not so remote as they once were because of the new internationalism of the air. With no spot in the world more than 60 hours distant from our doorsteps, new mosquito vectors and diseases or more virulent strains of existing diseases may arrive any day.

The answer to these new challenges must not be a feeble one. The words "too little, too late" are tragic reminders of unpreparedness. These new threats must be met with an all-out effort at home. If dengue-yellow fever vectors are reduced and malaria is traced to its deep endemic reservoirs and overwhelmed, the danger from mosquito-borne diseases will be practically eliminated.

MALARIA CONTROL ORGANIZATION



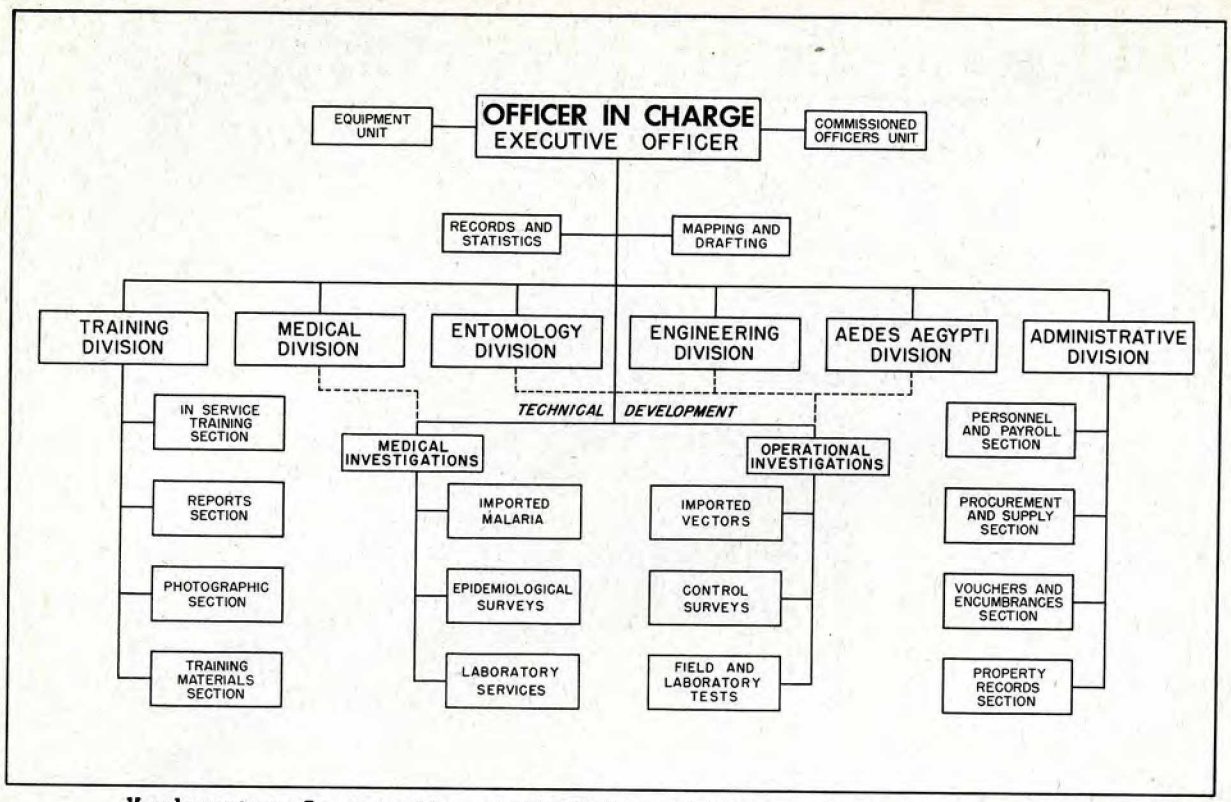
GENERAL ORGANIZATION

Malaria Control in War Areas was organized, with lines of authority from the office of the Surgeon General through the Bureau of State Services and the States Relations Division. It operates as an individual unit through its Headquarters Office in Atlanta, Georgia. Authority is exercised and responsibility discharged by the Headquarters Office in cooperation with the District Offices of the Public Health Service. Operation of the program is by the State Health Departments under policy and administrative direction of the Atlanta Office. Full use is made of the Public Health Service Liaison Offices in coordinating the effort of MCWA, the State Health Departments, and military authorities.

The operational unit is the "war area." Approximately 1800 war establishments are protected and these are grouped according to location, nature and extent of operations, so as to form 250 "war areas." The "area supervisor" is generally an engineer. He is in complete charge of his area and works closely with the sanitary officers in adjacent military establishments and with the local health officer.

MCWA personnel includes about 200 commissioned officers, 60 non-commissioned professional employees and 415 sub-professional, 138 clerical and 2400 custodial employees.

MCWA activities are closely related to other work of the U. S. Public Health Service. The Division of Public Health Methods has been helpful in publishing technical articles and has prepared numerous posters, hand bills, and other informa-



Headquarters Organization of the Office of Malaria Control in War Areas

tional materials needed in the course of in-service training and field work.

In cooperation with the National Institute of Health, investigations relating to returning malaria carriers are pursued to determine exotic strain virulence and transmission efficiency of local malaria vectors. Operational investigations are employed to develop and measure efficiencies of new insecticides and to increase the effectiveness of control techniques.

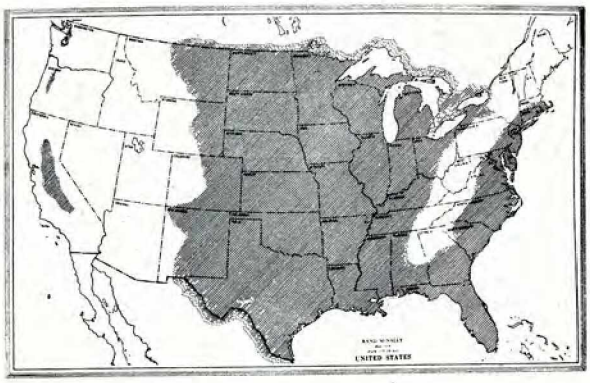
Foreign quarantine is vital to our national safety at all times, but the danger of importation of foreign diseases or vectors has never been greater than during the present emergency. Exotic disease vectors will certainly be introduced unless extraordinary measures are taken. MCWA entomologists have been detailed to the Foreign Quarantine Division for surveillance at major airports of entry.

HEADQUARTERS ORGANIZATION

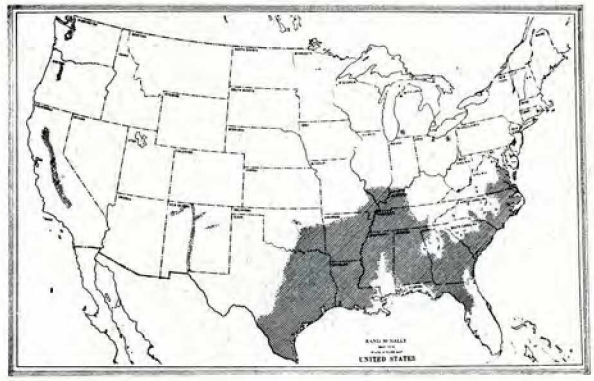
The Headquarters organization of MCWA includes the Executive Office with six supporting divisions: Medical, Entomological, Engineering, Administrative, *Aedes aegypti*, and Training. Balanced coordination of modern medical, entomological, and engineering sciences is employed to produce effective protection for war personnel with a minimum expenditure of manpower and materials. This associated partnership, serviced by an administrative division, has demonstrated its effectiveness. The Medical Division determines endemicity, locates foci of infection, and studies trends of the disease; entomologists determine densities and breeding areas of vectors and check control measures; engineers, analyzing these data, apply the mechanics of engineering science to accomplish effective and economical control.

The Training Division, primarily a service division, is responsible for the indoctrination and training of all new personnel, the production of training and operational materials, and for reporting progress. Supporting service units as indicated are attached to the Executive Office. Sections under the Administrative Division and Training Division perform the functions indicated by their respective names.

MALARIA, THE DISEASE



Malarious Area of the United States 1882



Malarious Area of the United States 1934-5

The map of malarious areas of the United States for 1882 shows that the disease was prevalent in 38 States from the Mexican to the Canadian border. In 1935 malaria was a significant problem in only 15 States, mostly in the southeastern part of the country, and today the disease has reached the lowest point in its history.

What has happened in the last half century? No comprehensive program of malaria eradication was attempted and anopheline mosquitoes still abound in nearly all parts of the country. Probably the answer lies in the advance of modern agriculture and drainage of the land, in the continued application of mosquito control measures by local, State, and federal agencies, and in the advance of education, with better housing and screening and the popularization of sprays for adult mosquitoes.

The downward trend of malaria is not so simple as it would appear from a comparison of the maps of 1882 and 1934-1935. Malariologists have shown that the disease fluctuates in the United States. With each upswing malaria increases in marginal areas where large numbers of susceptible persons are endangered. In alternate periods it decreases and practically disappears except in certain endemic foci or permanent pools of infection where it smolders quietly like a volcano between eruptions.

We are now at a critical point in the history of malaria in the United States. Although the disease has reached an all-time low, the return of large numbers of malaria carriers may upset this favorable situation. A rational approach to this problem appears to be supplementation of the present MCWA program. Vigorous anti-malarial measures must be applied in areas where factors are conducive to malaria transmission. Such a program requires precise answers to several questions: where are these areas; how extensive are they; if found, can the malaria hazard be neutralized by the methods of control available at the present time? The last question may be answered in the affirmative insofar as the vectors are concerned.

The first two questions are more difficult because potential foci and endemic foci are as elusive as individual malaria cases

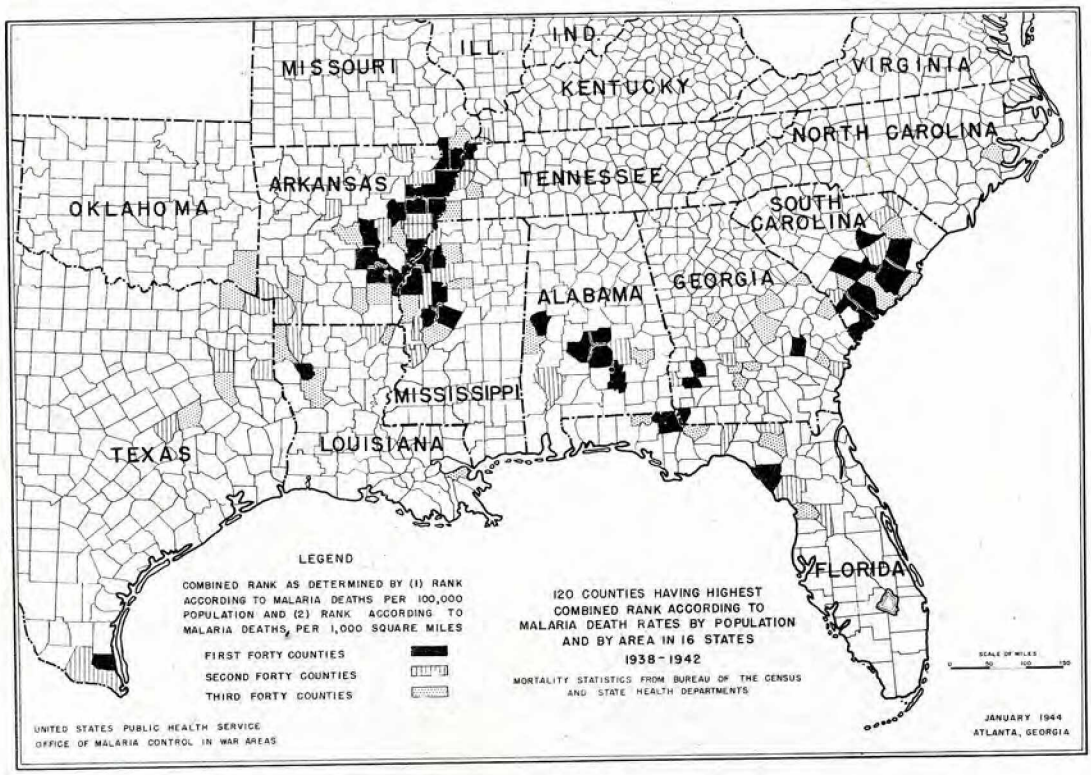
MALARIA SURVEYS

Existing information on the prevalence of malaria is inadequate. Reporting is notoriously poor and most cases are not confirmed by a blood smear. Self-treatment for alleged malaria has made chill tonics one of the South's most popular home remedies. Out of the morass of ill-defined malaria records, mortality data may be selected as a convenient and more

or less reliable starting place to determine the existing foci of malaria in the United States. A record of deaths from malaria for the period 1938-1942 was obtained from the Bureau of the Census and from State health departments. On the basis of death rates per 100,000 population and per 1,000 square mile area, 120 counties with the greatest malaria problem were selected. Since these are apparently the most malarious areas in the country

4. Information about previous surveys and other data from State and local health agencies, private physicians, hospitals, agricultural agencies, industries, druggists, and residents.
5. Evaluation of effect of physiographic features, housing, education, and other socio-economic factors on malaria.
6. Spleen surveys through schools.

A serologic test (complement fixation) for malaria may soon be available for



the spotlight has been focused on them in order to determine the malaria incidence, the local foci, and the factors that contribute to the perpetuation of malaria in each county.

Several methods of approach have been used by epidemiologists in the field:

1. Analysis of mortality and morbidity statistics.
2. Supplementary morbidity data from physicians, diagnostic laboratories, and questionnaires distributed through the schools.
3. Parasitemia surveys by thick film technique.

field surveys.

Mortality Surveys. Mortality statistics were selected as the most obvious starting point for the survey of malaria incidence. At first sight these records would appear to be positive and fool-proof since most of them are official records submitted by physicians. Actually, experience has shown that such data should be used with caution. Interviews with physicians indicate that the great majority of cases are not confirmed in the laboratory. Yet, in most cases, mortality records have been a useful guide in spotting areas of endemicity. In some counties, mortality

data coincide with the findings of the school morbidity survey. On the other hand, there was a striking variance in the two sets of findings in one county, where it was possible to interpret the school morbidity survey results more intelligibly in terms of what is known about physiographic factors and housing.

Morbidity Surveys. Records of reported malaria are another useful source of information but are even less reliable than mortality records. Many cases of malaria are never seen by a physician and, if seen, are not always reported. In one instance, doctors had reported only 25 cases in a county for 1943; but, when interviewed personally, they estimated that more than 1,000 cases had actually occurred.

There is a striking racial difference, too, in reporting malaria cases. In one small town almost all the reported cases from 1939 to 1943 were white, whereas almost all the deaths were Negro.

Additional morbidity information is obtained by various means such as private laboratory records, medical records of industries, Farm Security Administration, and house to house canvasses. In one county, people in every third house were interviewed for a history of malaria. It was concluded that, under the conditions of the survey, house-to-house interviews were too time-consuming to justify the questionable information obtained.

Surveys by questionnaires distributed through schools proved to be a useful method of gathering morbidity data representing all parts of a county. Despite the crudity of this method, it has helped materially in evaluating the extent of the malaria problem in each community, and especially in determining the distribution of the disease.

Questionnaires requested the following information: 1. How many persons, children and grown-ups, lived in your home during all of 1943? 2. Did any of these have malaria or chills and fever in 1943? 3. Did anyone in your home have malaria or chills and fever before 1943? 4. Location of house you lived in at end of 1943. 5. If you moved during 1943, how many miles did you move?

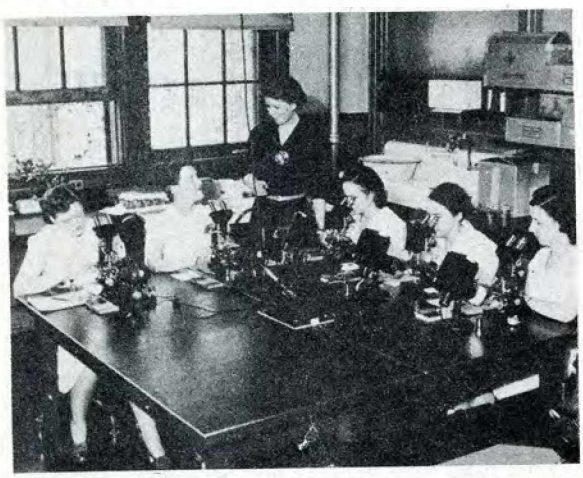
Teacher Distributes Morbidity Forms

Pupils Take the Forms Home

Parents Fill in Desired Information

Making Blood Smear

Parasite Surveys. The thick film technique for examining blood to determine presence or absence of malaria parasites has been widely used. To the diagnostician a "positive" slide is final evidence of malaria infection. However, he does not consider that a "negative" slide excludes the possibility of malaria. Several factors might cause a negative report even though malaria is present. Perhaps the parasites were so few that no parasites were found on the slide examined. Perhaps the person examined had been taking anti-malarial drugs which decrease the number of parasites in the circulating blood. If additional tests were made in cases where negative slides result, there would be a better chance of discovering malaria parasites in the blood.



Blood Slide Survey Laboratory at Memphis

Surveys based on a single slide for each person examined reveal at best only 50% of the actual number of malaria victims. Nevertheless, thick film surveys are the most reliable method now available for obtaining an index of the prevalence of malaria in the United States.

Because of the progressive increase in the number of malaria cases throughout the season, more than twice as many new cases of malaria are reported in the fall as in the spring. Considering the seasonal variation in malaria occurrence, the comparison of a 1942 fall survey and a 1934 spring survey gives a good indication of the decrease in malaria during those eight

Microscopic Examination of Slides

years. In the spring of 1934 blood smears collected in 15 southeastern States showed 5.8% positive; whereas in the fall of 1942 only .27% showed positive.

About 90 000 smears were collected in eight States during the fall of 1943. As of June 30, 1944, 25,408 of these had been examined with 28 positives (0 11%).

The striking difference between the 1934 spring and recent fall surveys clearly indicates a tremendous decrease in malaria. This decrease is confirmed by a marked though proportionately smaller decrease in reported malaria deaths.

Spleen Survey in a Grammar School

Spleen surveys have been conducted by a medical officer specially trained in the technique of spleen examination. The surveys included comparable data from malarious areas in Arkansas and from non-malarious sections of New York and Massachusetts. The surveys were confined to school children under 14 years of age because the spleen is easier to palpate in young children, school groups are easily approached, and the size of the spleen is more significant in childhood than in later life when chronic infections or varying degrees of immunity may have developed. Each child examined was questioned to detect any unusual disease history.

Results are shown in the table below. In Arkansas 24% of the children examined were found to have palpable spleens. Such figures would appear to be significant but for the fact that 14.7% of the children in New York and 12.3% in Massachusetts had palpable spleens. The real significance lies in the group with spleens larger than PDI (palpable only on deep inspiration). Many more children showed spleen sizes of 1, 2, or 3 in Arkansas than in the North. Even so, 1.2% for Massachusetts and 3.9% for New York are high figures in the absence of malaria and show a significant difference that is difficult to explain.

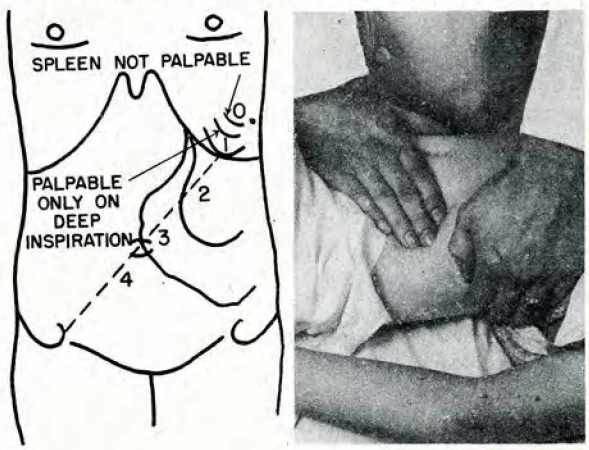
Judging from these surveys, splenomegaly must be interpreted with caution as a guide to the prevalence of malaria in areas of low endemicity.

The complement fixation test for malaria has recently been developed to the point where it shows promise. Utilizing the parasites of chicken or monkey malaria for the antigen, this technique may become a valuable survey method. Unfortunately it is not yet ready for field use, but tests are continuing in an effort to eliminate certain technical difficulties.

SPLEEN SURVEY - SPRING, 1944

White Children Who Arrived in County of Present Residence before March, 1943.

State	Exam.	Number Positive					% Positive		
		Total	PDI	1	2	3	Total	PDI	1,2&3
Arkansas	1,048	253	137	112	4	0	24.1	13.1	11.1
Massachusetts	838	103	93	9	0	1	12.3	11.1	1.2
New York	2,406	354	259	88	4	3	14.7	10.8	3.9

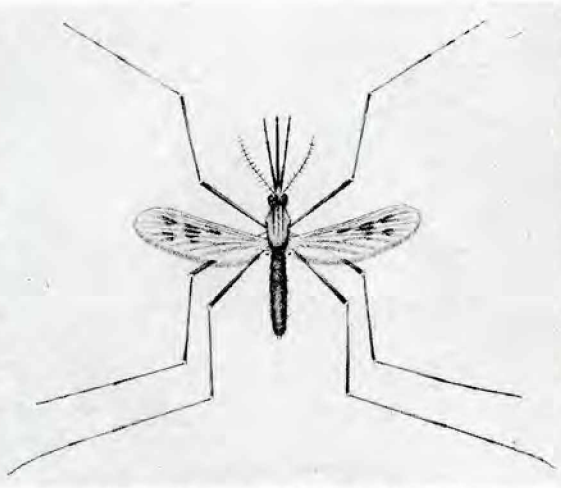


Spleen Examination. Classification According to Mark F. Boyd

In the search for the elusive malaria focus all known methods of surveying have been tried. Results must be evaluated by malariologists in cooperation with State and local health officers, because local conditions are all important in epidemiological work. There is still no really satisfactory criterion for quantitatively estimating the "malariousness" of an area. Mortality statistics, morbidity data, parasite surveys and spleen surveys all have their limitations. The best current procedure is to utilize a combination of all epidemiological methods.

MALARIA VECTORS

The anopheline mosquito is one of the most vulnerable links in the chain of malaria transmission. In malarious areas anopheline abundance is the most useful indication of where to concentrate control measures.



Anopheles quadrimaculatus Say

Once the malaria problem is defined, whether it be in the 120 most malarious counties, in potentially malarious military areas, or elsewhere, the first step toward control is to locate all sources of the vector mosquitoes. This task would be difficult if all species of mosquitoes were involved and only "shotgun" control methods were available. However, advancement has been made far beyond that stage in applying anti-mosquito measures for malaria control, and cure-all methods are no more efficacious here than in the treatment of human ills.

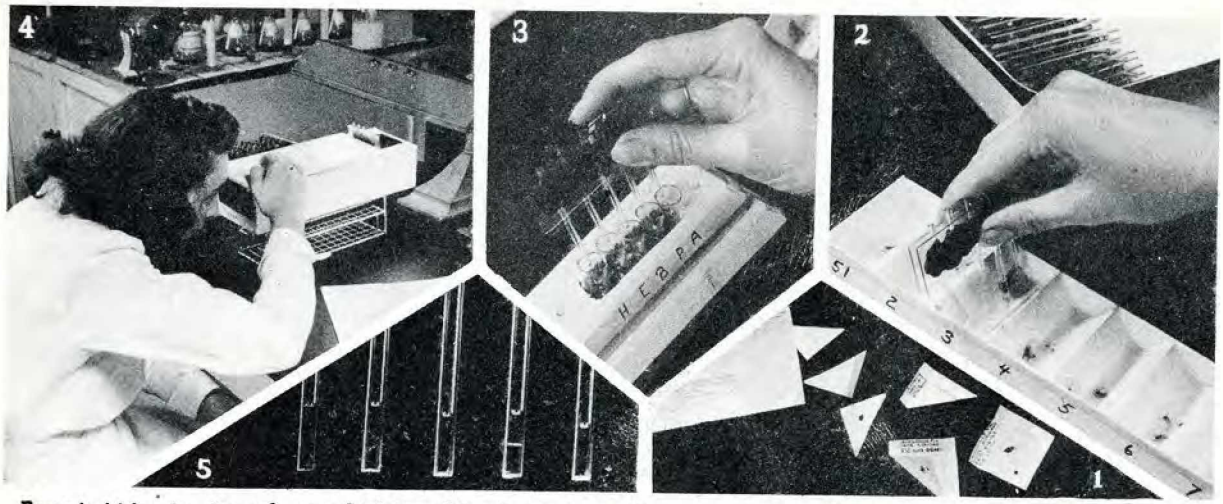
ANOPHELES SPECIES CONTROL

The principle of *Anopheles* species control or "species sanitation" was first enunciated by Darling in Panama in 1910. Darling noticed that for any given area there is usually but one important malaria vector even though other species of *Anopheles* may be present in abundance. Subsequent work throughout the world has proved the soundness of this principle.

There are 12 species of anopheline mosquitoes in the United States, all of which are capable of transmitting malaria, as proved by laboratory tests. Fortunately, only three of these are important malaria vectors in nature and in general each of these reigns supreme in its own territory: *Anopheles quadrimaculatus* Say in the Eastern and Southern States; *Anopheles albimanus* Wied. in the lower Rio Grande Valley; and *Anopheles freeborni* Aitken in the Western States.

One factor that determines the importance of a malaria vector is, of course, the degree of susceptibility of the mosquito to each of the types of malaria parasite. However, this is not the most important factor. Above all else, the habits of the mosquito species in relation to the habits of the human population within its range must be considered. What does it matter that a species is capable of transmitting malaria if it never bites human beings? This situation occurs in Europe, where it has been called "Anophelism without malaria." It has been known for a long time that in some parts of Europe apparently good vectors abound in the absence of malaria, while in others the vectors are scarce where the disease is endemic. Rice and Barber investigated the situation by testing the blood meals of 37,000 anophelines by precipitin tests. It was shown that *Anopheles maculipennis* Mieg. is not a homogeneous species but is divisible into six races. Three of the races proved to be cattle feeders and thus were not concerned with malaria transmission, whereas the other three fed principally on humans in Spain, the Mediterranean, and the Balkans.

The feeding habits of *Anopheles* in this country are being investigated at the MCWA Carter Memorial Laboratory in Savannah, Georgia. Recently engorged female anophelines are collected during the routine inspection of adult stations throughout the



Precipitin tests of anopheline blood meals. Blood samples (1) are soaked in saline (2) and then drawn into capillary tubes with human, equine, bovine, porcine, and avian antisera (3). Blood source is determined by viewing (4) precipitate (5) in one of the tubes.

MCWA program. The Rice and Barber technique of mass precipitin testing is used to determine the source of the blood.

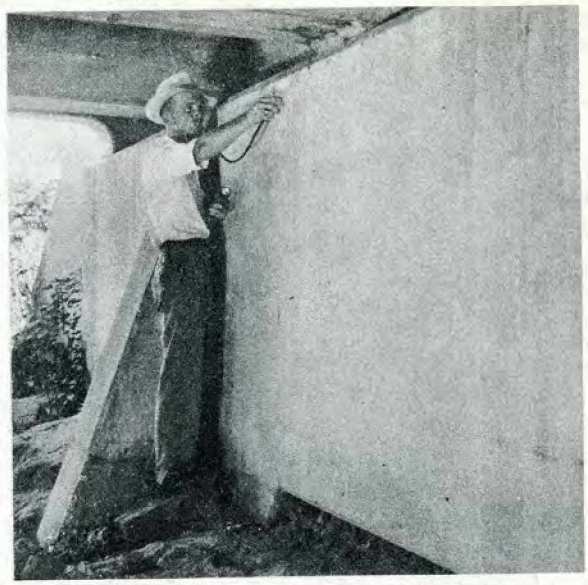
Essentially, this technique involves soaking the blood from filter paper on which it is originally collected, and bringing the resulting mixture (antigen) into contact with prepared human, equine, bovine, porcine, and avian antisera in five capillary tubes. In the appropriate tube, a precipitate appears at the point of contact between antigen and antiserum, indicating the source of the original blood meal.

Results of tests of 13,139 satisfactory samples from 21 different States are shown in the chart below. Many more samples will be required to insure significant results, but these preliminary figures bear out the fact that six of our commonest anophelines feed largely on bovine blood. *Albimanus* shows the greatest preference for human blood, based upon a very small series of tests. It is expected that future tests will show regional differences in preference for human blood and consequently have a direct bearing on control practices.

RESULTS OF PRECIPITIN TESTS SHOWING NUMBER AND PER CENT OF TESTED SPECIMENS OF SIX SPECIES OF *ANOPHELES* FEEDING ON SPECIFIED HOSTS - TO JUNE 30,1944

Species	Human		Equine		Bovine		Porcine		Avian		No reaction		Total No.
	No.	Per cent	No.	Per cent	No.	Per cent	No.	Per cent	No.	Per cent	No.	Per cent	Tested
quadrimaculatus	366	4.2	1479	16.9	4646	53.0	1041	11.9	228	2.6	997	11.4	8757
punctipennis	39	3.0	240	18.4	756	57.8	154	11.7	25	1.9	94	7.2	1308
freeborni	27	4.4	70	11.3	384	62.1	25	4.1	5	.8	107	17.3	618
crucians	61	3.9	146	9.4	870	56.1	194	12.5	88	5.7	191	12.4	1550
pseudopunctipennis	21	3.8	33	6.0	401	73.0	25	4.6	12	2.2	57	10.4	549
albimanus	30	8.4	19	5.3	243	68.1	15	4.2	8	2.2	42	11.8	357

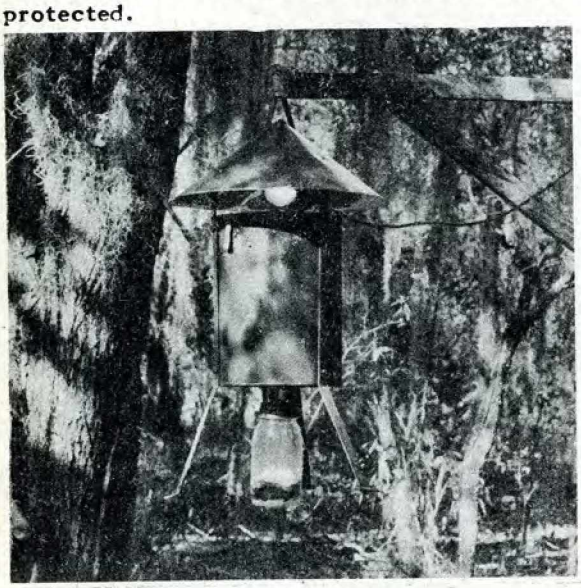
Examining a Larval Breeding Place



Examining an Adult Resting Place

ANOPHELINE SURVEYS

When control work is requested, the entomologist first makes a thorough survey to determine the density of anopheline adults. This is done by collecting adults from a series of natural and artificial resting places during the daytime and from light traps and bait traps at night. Additional data are obtained from biting records. If adult densities are high enough to constitute a malaria hazard, a survey is made of possible breeding areas within flight range of the place to be protected.



Mosquito Light Trap

The mere presence of anophelines, even though they are abundant, is not sufficient to justify a malaria control program. The information must be evaluated in terms of the local situation. What is the history of malaria in the area? What is the present malaria hazard? How important is it to the war effort or to the public health to prevent or control malaria in the area? Answers to these questions must come from local health officers in conference with trained malariologists. Practical considerations, such as availability of funds for control purposes and the economics of the control problem must be taken into consideration.

If it is decided that a control program is necessary, or that the locality should be kept under surveillance, a control zone is set up. The procedure in this case is to locate all breeding areas within flight range of the area to be protected and to select representative adult stations. For convenience in evaluation of records, the zone is divided into "A", "B", "C", or "D" sections indicating successive quarter-mile distances from the protected territory. "E" stations are located more than one mile distant and serve as an index to anopheline populations under uncontrolled conditions. Inspectors sample all stations regularly. Particular attention is paid to the number of adults in the criti-

cal "A" stations, i.e., those nearest the protected area. When significant numbers of *Anopheles* mosquitoes are found in adult stations, the source of breeding usually is revealed by high counts at one or more larval stations. Continued high adult counts in "A" stations may be due to ineffective larvicidal work, undiscovered breeding places, formerly non-breeding areas coming into production, or unusual flights from extensive breeding areas outside the control zone.

HABITS OF MALARIA VECTORS

The malaria vector of the western United States, *Anopheles freeborni*, is usually associated with seepage areas adjacent to irrigation canals and favors clear, shallow, sunlit water with some growth of algae. Recent surveys along the coast show that it also breeds in brackish waters with a saline concentration equivalent to 17% sea water. The flight range is very great because of fall "pre-hibernation" flights and spring "emergence" flights during which the species migrates distances of 10 or 15 miles.

Conference with Health Officer

The main malaria vector in the Southern and Eastern States, *Anopheles quadrimaculatus*, breeds chiefly in permanent fresh water pools, ponds, and swamps that contain aquatic vegetation or floating de-

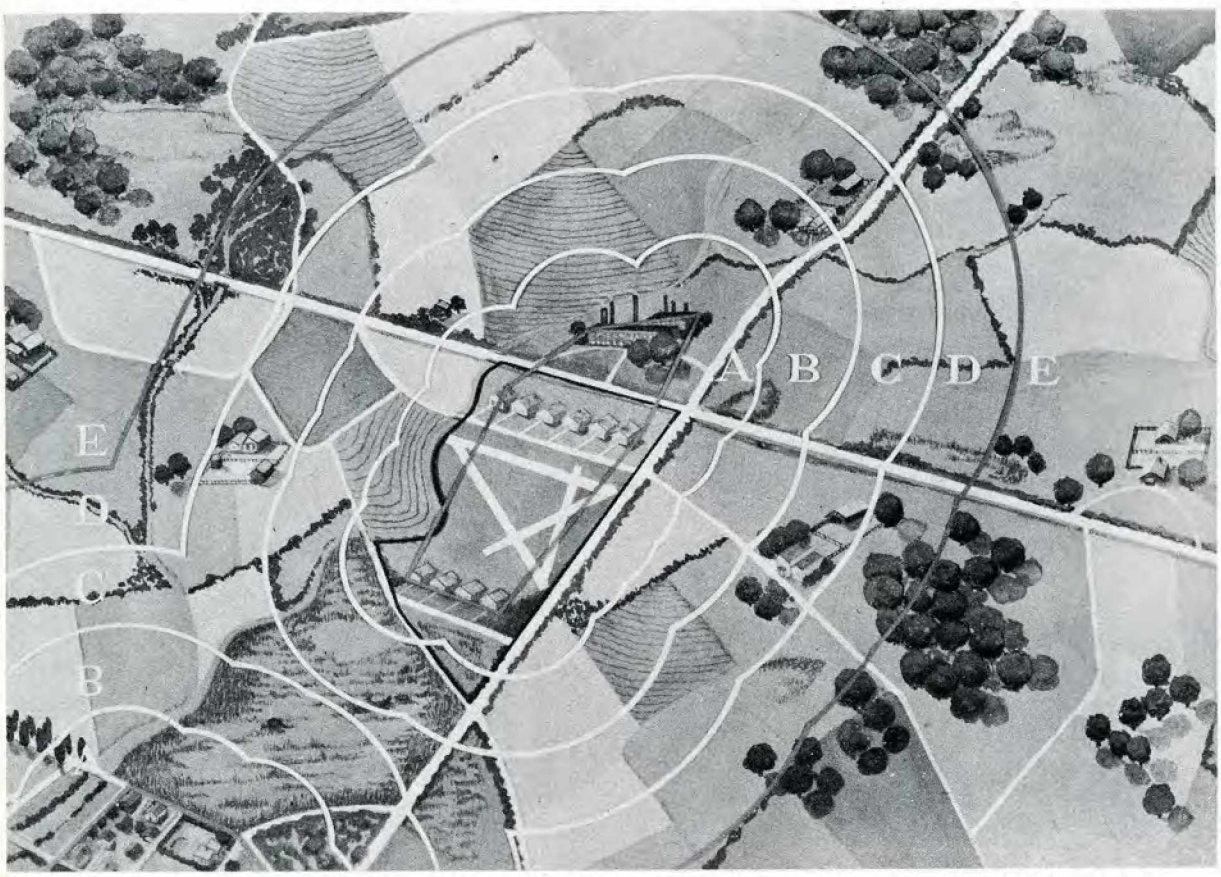
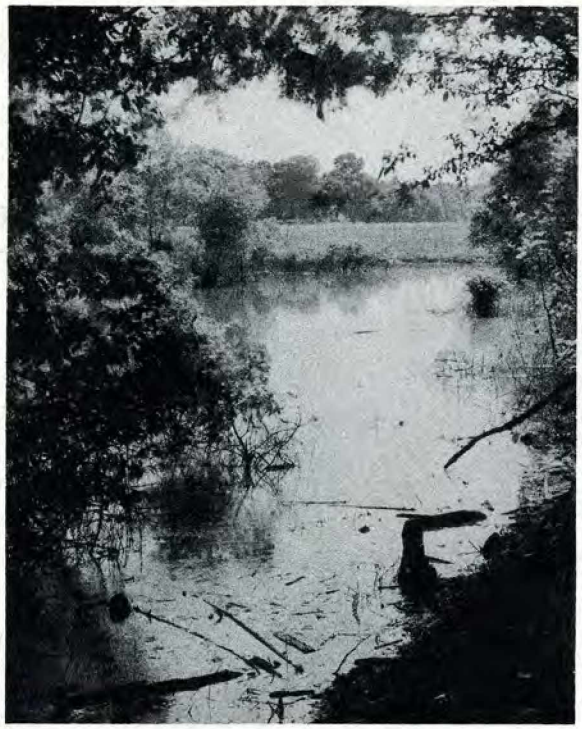


Diagram of a Control Zone Showing Successive Distances from War Establishments



Anopheles quadrimaculatus **Breeding Place**

Anopheles albimanus **Breeding in Hoof Prints**

bris. It does not normally fly more than one mile, so this distance has been taken as a standard in planning control.

The Neotropical *Anopheles albimanus* invades the Rio Grande Valley from Mexico and is the principal malaria vector in Puerto Rico, Jamaica, and other Antillean islands. It occurs commonly amid mats of floating vegetation in large bodies of water such as ponds or lakes but is also found in ground pools with algae. The larvae thrive in fresh water fully exposed to the sunlight and in brackish water as well. Adults may fly as much as 2½ miles, so control zones must embrace a larger area than in the case of *quadrimaculatus*.

Generalizations on the habits of anophelines are valuable. However, it has been said that mosquitoes are illiterate--that they have not read the books and hence do not know how they are expected to act. There is endless variety in the habits and idiosyncrasies of mosquitoes. Therefore, it is important that careful entomological work precede the inauguration of control and that inspection be maintained in order to determine any unusual habits in the specific locality concerned.

EVALUATION OF CONTROL MEASURES

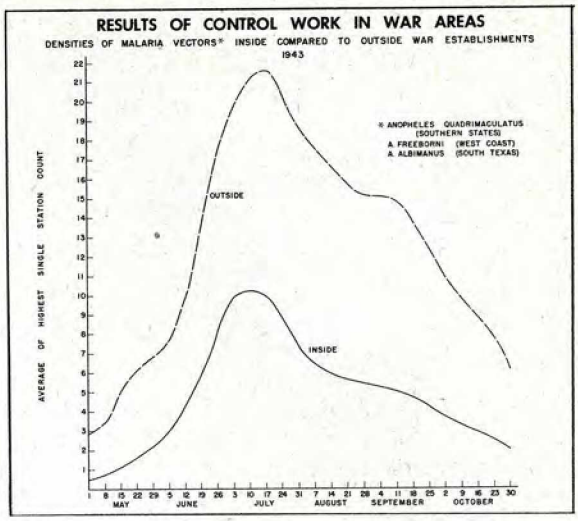
Results of malaria control operations expressed in terms of gallons of oil sprayed, tons of paris green dusted, miles of ditches cleaned or dug, or man hours expended are unsatisfactory for evaluating the effectiveness of control. The real results of malaria control work in any community can only be measured by a decrease in incidence of the disease. This criterion is not applicable at present because there are so few malaria cases. However, the effectiveness of anti-mosquito measures can be gauged by the decrease brought about in density of the vector species and this decrease indicates the extent to which potential malaria transmission has been reduced.

During 1943, the densities of malaria vectors in areas included in the MCWA program were maintained at a satisfactory level in 86% of the protected zones. A zone is considered satisfactory if no "A" station shows an adult count of more than 10 for three consecutive weeks. The 14% of unsatisfactory zones were distributed in 17 of the 21 States under control, so no

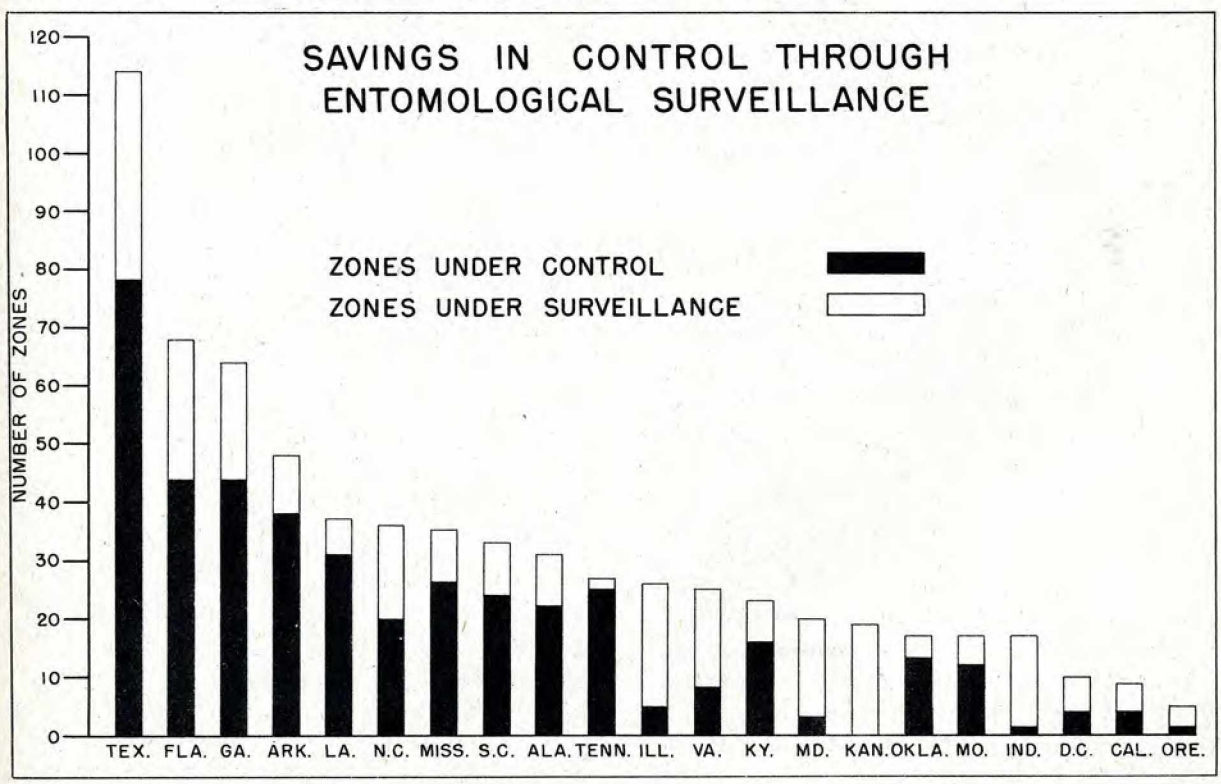
general failure occurred in any one State.

Results of the control work as a whole during 1943 show that average densities inside the control areas did not exceed counts of 10, whereas average outside densities reached 22 at the peak of the season. Highest single station counts inside protected areas are compared to those in adjacent unprotected zone. This comparison is based on averages of the highest single counts from each control area, not on averages of all station counts. Thus, areas are rated by their worst conditions with respect to "quad" densities. Though perhaps a rather severe criterion, this measurement was adopted because average figures for an entire area might mask unsatisfactory conditions in a particular section of the area.

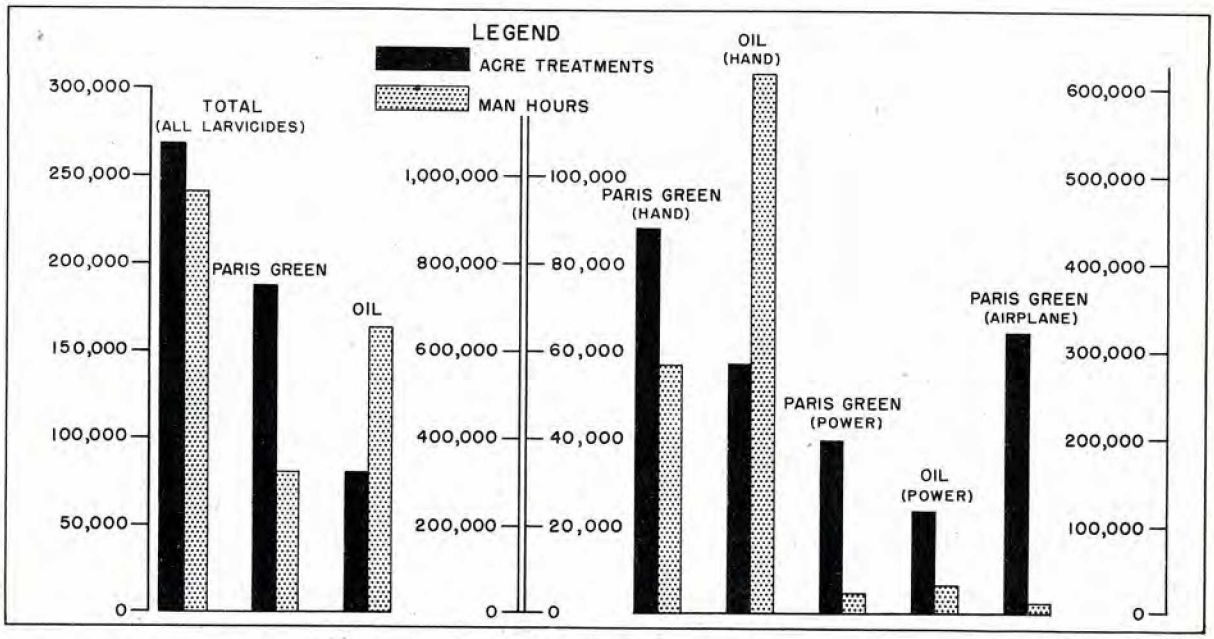
One of the chief functions of the entomologist is to obtain the information that will make it possible to limit operations to areas which show a definite need for anopheline control. Preliminary surveys or routine inspections (Entomological Surveillance) have prevented two-thirds as many (257) projects being inaugurated as the number of actual projects in operation.



About 80 professional entomologists and general biologists are employed to carry on entomological phases of the MCWA program. They are assisted in routine survey work by sub-professional employees who serve as area inspectors. The entomologist is an integral part of the "malaria team." He supplies the information on which an efficient program can be planned and prosecuted.



MALARIA CONTROL



Summary of Larvicidal Operations

The duties of the engineer in the malaria control team are to determine control methods, to direct mosquito control operations, to survey and design proposed drainage construction, and to prepare maps which guide field project activities. Heavy construction is important on larger or more permanent projects, with larviciding, clearing, and temporary drainage as the more frequently employed emergency measures. MCWA engineering is primarily a management enterprise.

Since MCWA is a war emergency program, temporary larvicidal control measures are used wherever they accomplish the desired objectives, thus saving both money and critical equipment needed in combat areas. Drainage is utilized where larvicidal control is inadequate or when the cost of drainage may be amortized in five years or less in terms of the annual larvicidal cost. Special local conditions have necessitated the use of such other methods as dredging, hydraulic fill, flood gate installation, cleaning, sanitary fill, diking, vertical drainage, ditch flushing, ditch grading, and destruction of adult mosquitoes. Careful analysis of the problem in any area is necessary before deciding on the type of control measures to be applied.

Project activities are planned insofar as possible to avoid seasonal peaks in labor and supervisory requirements. This aim has been accomplished in the past by concentrating on drainage construction, heavy clearing, stream channeling, mapping, and drainage surveys during the cold months and on larviciding and other recurrent work during the malaria season. By distributing work in this manner it has been possible to conserve manpower and tc maintain a seasoned field organization.

LARVICIDING

During the year the basic control operation of the MCWA program was the application of larvicides to *Anopheles* mosquito breeding areas. In Puerto Rico, southern Florida, and southern Louisiana, larvicide was applied throughout the year. Proceeding northward the larviciding season was progressively reduced to as little as two months in some of the marginal States

The average larvicidal crew consisted of a foreman and four oilers or dusters, equipped with a truck and the necessary tools and supplies.

Oil Spraying. The majority of the larvicidal acre applications were made with paris green but oil was used exclusively in many zones and accounted for the bulk of the financial and labor expenditures. The rate of application varied in different types of breeding places from 12 to 50 gallons per acre, with 18.9 gallons per acre as the average. Eighty thousand seven hundred and five acre applications of oil were made during the year at a unit labor cost of 8.07 man-hours per acre application.

Oil larviciding was performed principally by hand, using approximately 3,000 knapsack and compressed air sprayers. The use of power equipment was increased during the year, wherever possible, in order to conserve manpower and to reach breeding places inaccessible to hand labor. Power equipment employed included several oil-water centrifugal pumps and 50 high-pressure sprayers which were installed either on trucks or in boats. Power units were found to be particularly effective in oiling water surfaces covered with heavy flotage or dense vegetation. The average acre application cost of oil larviciding

Knapsack Sprayers in Operation

Hand Duster in Operation

was $9.55 by hand and $2.26 by power methods, including cost of labor, larvicides, and equipment.

Paris Green Dusting. Paris green was employed extensively as a larvicide in areas where oiling was impracticable, ineffective, or unduly expensive.

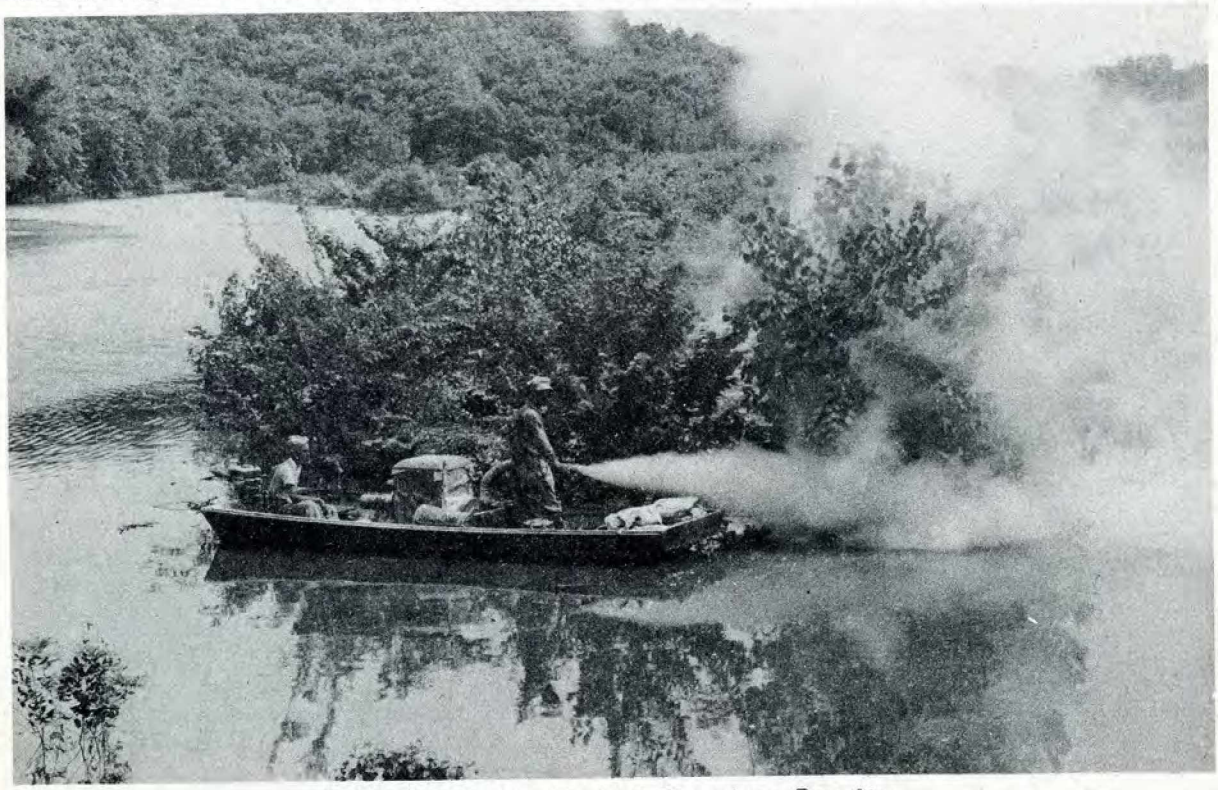
Hand dusting was the most common method of application for breeding areas of relatively small size and readily accessible to men on foot. Approximately 1500 rotary blower dusters were used. The effective radius of application by hand dusting ranged from 50 feet in the tropics, where air turbulance is greater, to 150 feet in some of the more favorable areas of the continental United States.

During the year 187,799 acre treatments of paris green were made, 45% by hand, 21% by power duster, and 34% by airplane. Respective costs per acre application were $2.98. $0.65, and $1.06. Dust mixtures varied from 4% to 10% paris green by weight for hand and power dusting, and 15% to 25% for airplane dusting. Rates of application varied from one-half pound of paris green per acre in relatively clear areas to two pounds per acre in densely vegetated areas or in high-flying airplane operations over swamps. The average rate of application of paris green was 1.3 pounds per acre and 1.7 man hours were expended per acre application.

Some of the most prolific malaria mosquito breeding areas in Arkansas, Louisiana and coastal Texas are irrigated rice fields which are best controlled by airplane dusting. Since the possibility of damage by paris green to the rice crop was an important consideration, an experimental project was established at Stuttgart in cooperation with the Rice Branch Experiment Station of the University of Arkansas. A two-acre section of Arkansas Fortuna rice was dusted at weekly intervals for several weeks during the growing season. As a result of the experiment it was concluded that paris green mixtures, at concentrations utilized for larvicidal purposes, had no appreciable effect on the yield of rice grain or straw. This finding confirmed studies made in other parts of the world where the irrigation of rice creates a major malaria hazard.

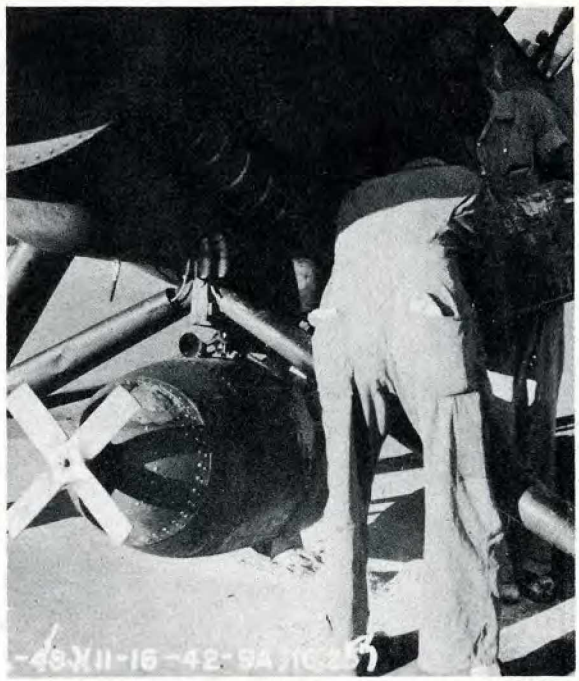
Paris green was used almost exclusively on the MCWA program in Puerto Rico. Peak monthly consumption of paris green was 4.5 tons. About 340,000 gallons of oil per month would be required to larvicide the same acreage. The full-time use of a tanker to transport oil to Puerto Rico and of many trucks for its local distribution would be necessary to supply this demand.

Forty power dusters and numerous power mixers were utilized on the MCWA program. Most of this equipment was mounted on motor-boats or trucks. Application by boat was found preferable in navigable streams and lakes having breeding areas along the margins. Power dusting from trucks is particularly suitable where access trails are available or easily constructed; where trees grow over the entire watered area favoring extensive breeding and preventing boat navigation; and where the most remote breeding place in the area is within dusting radius of the shore line (approximately 600 feet). In Puerto Rico, ox carts have been used to power-dust breeding places which were inaccessible even to four-wheel drive military vehicles. Large shallow water marshes, which are inaccessible even to carts, have been power-dusted by two laborers carrying a 3/4 horsepower duster on a hand barrow. The principal advantage of power dusting over other methods of larviciding is the



Power Dusting to Control Shoreline Breeding

Airplane Dusting on the Potomac River



Airplane Dusting Unit in Puerto Rico

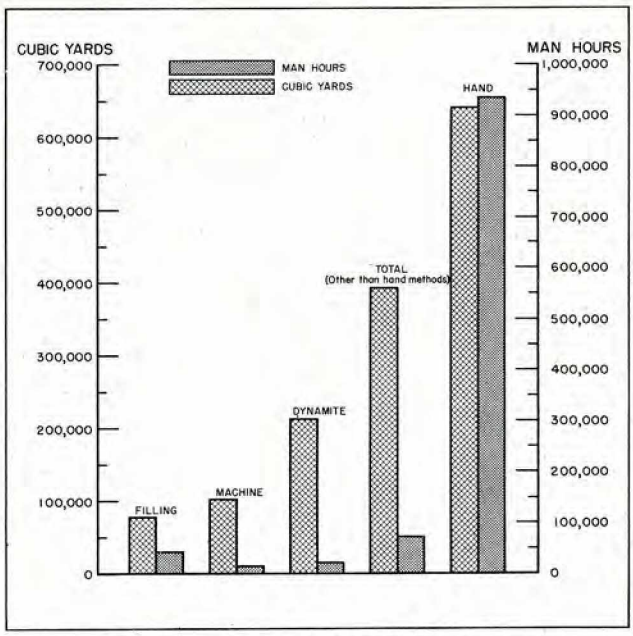
greater radius of application obtained.

The airplane was used in the States of Virginia, Mississippi, Arkansas, Louisiana, Tennessee, and in Puerto Rico for dusting areas which were too large or inaccessible for power dusting. About 350,000 pounds of 25% paris green mixture were applied in 64,780 acre applications on nine airplane dusting projects. The effectiveness of airplane dusting has varied widely, being lowest in wooded swamps with trees of widely varying height. Optimum results were obtained in large water chestnut areas of the Potomac River. This low-growing, imported aquatic plant was so dense that power dusting by boat was impossible, and airplane dusting was the only alternative. Planes dusted parallel strips 40 feet wide at a flying height of 10 to 15 feet above the water and at a speed of 70 miles per hour. Over-all larval reductions of 97% were accomplished. Cost per hour for plane and pilot was $75.00, but the average over-all cost was low since even a small plane can dust up to 200 acres per hour.

Organic Larvicides. On water supply impoundments and in other special situations where there was some objection to the application of paris green or oil, both the original and a modified New Jersey larvicide were effectively utilized. This larvicide was prepared with a commercial mixture of pyrethrum in oil. In the Norfolk-Portsmouth area it was applied on water supply lakes with a power pressure sprayer.

Phenol larvicide was used in a few areas. This larvicide is quite toxic to animal and vegetable life and also has the undesirable characteristic of quickly permeating water. It therefore must be applied according to the volume rather than the surface area of water treated.

A promising new insecticide, dichlorodiphenyl-trichloroethane, or DDT, has been under investigation during the past year. When it becomes available in sufficient quantity for use on the MCWA program, a considerable revision of control procedures may be necessary. Field tests are being conducted at Memphis in cooperation with the Division of Malaria Investigations of the National Institute of Health and at the Savannah MCWA laboratory. DDT shows unusual possibilities as a larvicide in oil, and as a residual spray for killing adult mosquitoes. It is also being tested as a larvicide to be added to irrigation water in rice fields, at Stuttgart, Ark.



Earth Removal in Relation to Man-Hours

DRAINAGE

Drainage is generally the most satisfactory method of malaria control; but on an emergency program, especially in temporarily inhabited war areas, it is secondary in extent to larviciding. On the emergency MCWA program, breeding places are drained if they cannot be larvicided effectively; if the cost can be amortized within five years or less through savings realized in larvicidal expenditures; or if critical manpower shortages coincide with the mosquito breeding season and winter drainage will materially reduce summer manpower requirements.

During the winter a maximum of 63 major drainage projects were in operation in 46 areas of 13 States and Puerto Rico. Since a majority of the malaria mosquitoes in the continental United States do not fly more than one mile, drainage was usually concentrated within this radius. Where excessive breeding did not occur between the one-half mile and one mile radius, control of this area by larviciding was, in most cases, sufficient. In a few instances it was necessary to install drainage works past the one-mile radius in order to obtain satisfactory outlets. On MCWA projects in the West Indies, where *A. albimanus* is the vector, it was often necessary to perform extensive drainage as far as two miles from the protected population, due to the longer flight range and more intensive breeding habits of this species.

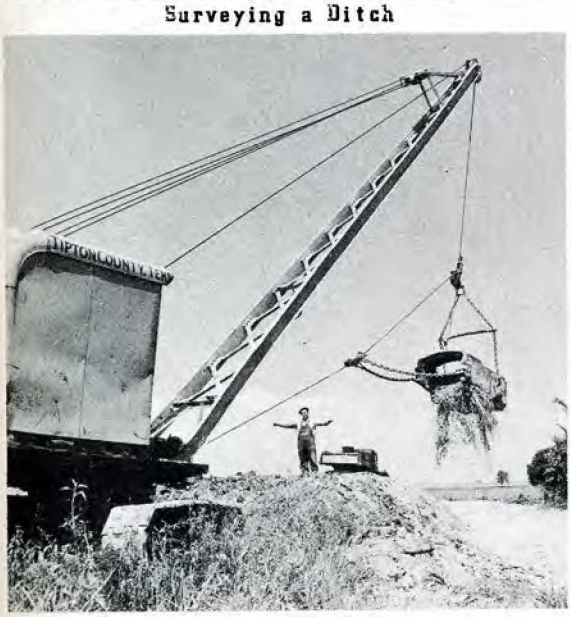
While practically all of the less expensive drainage enterprises have been completed, a number have not been undertaken due to costliness which would far exceed MCWA appropriations. These comprise projects requiring the hydraulic filling of hundreds or thousands of acres of river marsh or swamp, or levee construction and pumping to dewater other areas of similar size and character. In some instances the estimated cost of individual projects of this type exceeds a million dollars.

Although nearly all drainage work originally projected around the older military establishments has been completed, many new areas have been added recently. These consist mainly of newly established prisoner-of-war camps and military hospitals. Major drainage is seldom justifiable around prisoner-of-war branch camps because of their temporary nature. However, larvicidal work has been supplemented by drainage at some of the more permanent base camps.

Plain Earth Ditches. On small ditches

the bulk of construction has been accomplished by hand labor. The life of this type of drainage has been designed to conform to the duration of occupancy of the protected site. In most instances plain earth ditches have been dug without lining, sodding, erosion control, or appurtenant structures. The average cost for this type of excavation where performed by hand labor was $1.46 per cubic yard. One thousand fifty-nine miles of hand ditching were completed during the year, involving over 600,000 cubic yards of excavation.

Surveying a Ditch



Dragline Ditching

Dynamite Blast

Dynamite ditching was used extensively by MCWA. Most of the larger ditches were in swamps and low areas where soil conditions and the high ground water table favored propagation-dynamiting but impeded satisfactory mechanical or hand excavation. Under these conditions dynamite is more economical and more rapid. After the right-of-way is cleared, a crew of three to ten men can blast 750 to 3000 feet of channel per day. An example of economical dynamite ditch construction is an 18,000 foot ditch which was blasted in eight days at Round Pond, within one mile of Newport, Arkansas, at a cost of $4,707. The cost of larviciding this 200-acre pond was estimated at $4,705 for a single season. A total of 192 tons of dynamite was used on the MCWA program to blast 60 miles of ditch at a cost of 27¢ per cubic yard (rough excavation only).

Dragline drainage has been performed principally by contract, although some work has been carried on with MCWA owned equipment. Twenty miles of this type of ditch were dug.

Sub-surface drainage has been practiced in lieu of open drainage wherever it was practicable and more economical. This type of drainage is particularly suitable for the interception of underground seepage, drainage of waterholding streams and ditches, and the dewatering of wet pasture lands. Twenty-six thousand eight hundred and four feet of sub-surface drains have been constructed.

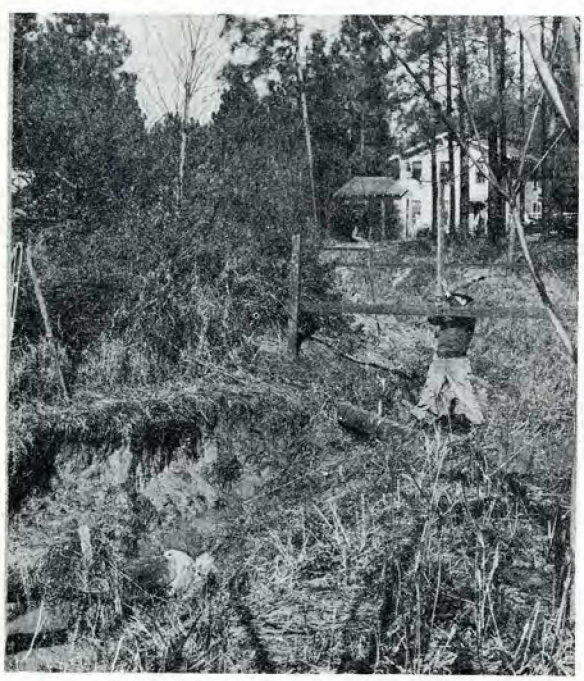
Resourceful use was made of locally

Subdraining with Poles

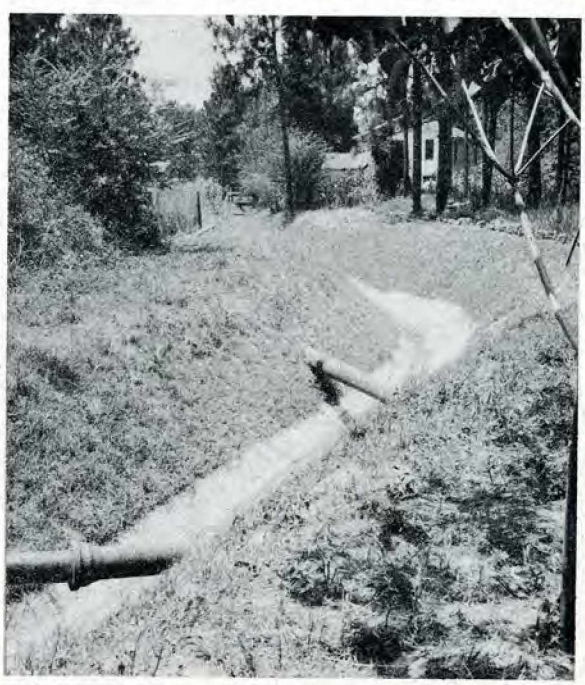
available materials on the smaller subdrainage projects. Many French drains were constructed with poles cut on the jobsite and covered with a filter of pine needles. On the more extensive sub-drainage projects, hard-burned terra cotta agricultural tile and butt-joint cement mortar pipe were most commonly used. Lateral lines were generally four to six inches in diameter, with intercepter and outfall lines ranging from 6" to 15" in diameter. All cement mortar pipe was produced on the job by the dry mix process, or furnished pre-cast by local agencies.

Ditch Lining. Approximately 60,000 linear feet of permanent ditch lining were installed by MCWA operations. This work was limited in the United States to a few permanent establishments where materials were furnished by property owners or local governments. The use of lining was more extensive in the tropics where malaria mosquito production is more difficult to control and where the malaria hazard is greater; but even there, installation of MCWA-produced ditch lining has been confined to the vicinity of permanent military establishments. Under an exchange agreement with the Army and Navy in Puerto Rico, pre-cast ditch lining was produced by MCWA at its central concrete products plant for installation in various posts and bases throughout the Island. Perpetual easements were obtained by the U. S. Engineers at all locations where lining was installed. Most of the lining was precast. Ditch banks were stabilized with Bermuda grass, planted generally by the "stolon" method.

Culverts. Highway and railway fills across swamps frequently contribute to malaria mosquito breeding. Right-of-ways



Old Ditch before Lining



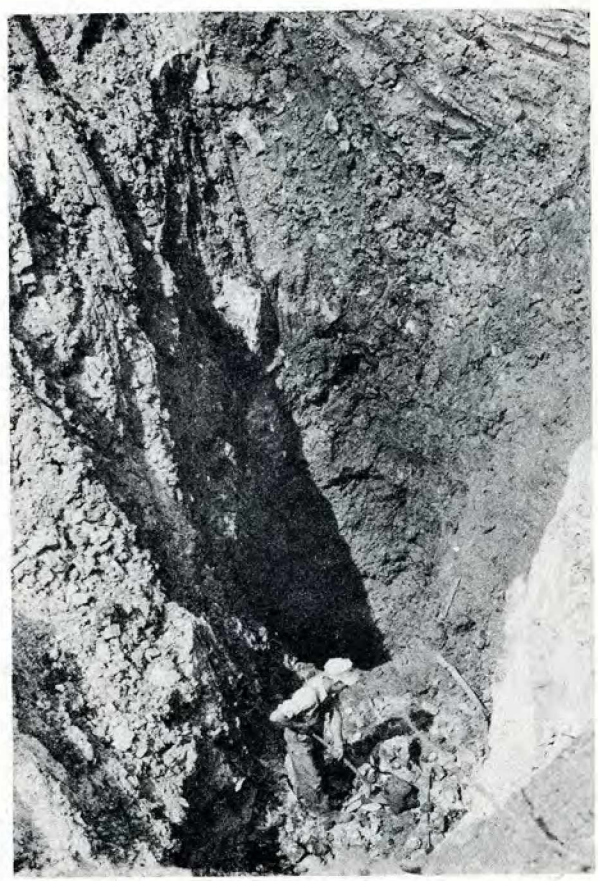
Ditch Sodded with Bermuda after Lining

Before Vertical Drainage

After Vertical Drainage

cleared through swamps on either side of a roadbed expose water surfaces to sunlight, thereby encouraging the growth of "quad-favorable" aquatic vegetation. When earth is excavated from a low area to provide material for the fill, a permanent water hole is created, especially when culverts have been installed too high for residual drainage. In a number of cases these problems have been corrected by lowering cross-drainage culverts or "jacking through" smaller culverts at lower elevations.

Special types of drainage were used where they offered the best solution to the control problem. At Jackson Barracks, La., a levee and a manually-operated flood gate were constructed. At Macon, Ga., and in Puerto Rico pumps were used for drainage. An inverted siphon was installed at Macon, Ga. Hydraulic dredging was utilized effectively at Leesburg, Fla., and Macon, Ga., and vertical drainage at Jefferson Barracks, Missouri.



Constructing Vertical Drain

OTHER METHODS OF CONTROL

Filling. Filling provides permanent elimination of mosquito breeding places. About 80,000 cubic yards of fill were placed during the year at a cost of $0.61

per cubic yard. The following methods of filling were employed on MCWA projects:

Filling by Bulldozer. This method is economical where the length of haul is short. If the bulldozer is followed by a highway grader, no hand labor finishing is necessary. This system was used with excellent results in Memphis, Tenn. and the coastal areas of South Carolina.

Filling by the diversion of streams carrying a heavy load of silt has been used in low swampy areas adjacent to a raised stream bed. Roadside ponds were filled by diverting into them the flow of silt-carrying roadside ditches. The cost of this type of filling is negligible, but its use is limited to special situations. Successful projects of this type were operated at Valdosta, Ga. and Tallahassee, Fla.

Sanitary Fill. This method was used to eliminate a breeding area at Paducah, Ky. When used, mixed garbage was covered at the end of each day's work with earth.

Result of Stream Diversion Fill

Other fills were made with uncovered trash and ashes.

Filling by Dragline. Spoil excavated by dragline in the construction of drainage canals was used to fill low places within reach of the machine.

A small amount of miscellaneous filling was accomplished by dump trucks, drag pans, hand labor with wheel barrows, and hydraulic dredges.

Filling by Hydraulic Dredge

Drainage Maintenance. Cleaning and maintenance of drainage ditches are important elements in MCWA operations. They serve the joint purpose of preventing breeding in the ditches themselves, and of maintaining hydraulic functions in order to avoid the re-establishment of breeding conditions in the areas drained. Some use was made of free crankcase oil and of worn cutting oil from machine industries as an herbicide to kill vegetation in drainage ditches and along their banks. A wide ditch in Missouri was choked with emergent vegetation providing ideal breeding places for "quads." The situation was corrected by cutting a longitudinal trench through the vegetation along the bottom of the ditch, thus producing a cunette where summer flow of water was confined. Approximately 1320 miles of ditch cleaning was accomplished during the year.

Clearing. Routine clearing is necessary in larvicidal and drainage maintenance work. During the year heavy vegetation was removed from about 8,000 acres of controlled area. Clearing around the shore lines of swamps and ponds is carried on in order that laborers may apply larvicide uniformly; trails are cut to provide access to the breeding areas; ditch banks are cleared preparatory to larviciding or drainage maintenance; channels are snagged to facilitate small boat navigation; and

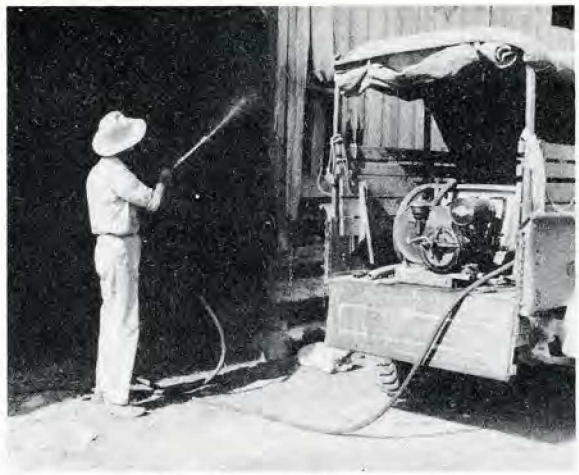
over-hanging tree limbs are cut to prevent flotage collection. Care is exercised in carrying out this work to prevent increased malaria mosquito breeding as a result of shade removal.

Large scale clearing of water chestnut in the Potomac River to effect permanent elimination was begun. This aquatic plant is an annual with a growing season that coincides with the mosquito breeding season. The plants are cut when they become dense near the end of May, before the chestnuts mature. Cutting was partially financed by MCWA and was carried on by the Corps of Engineers, U. S. Army.

Clearing of aquatic vegetation is also important in resacas near Brownsville, Texas. Large hinged rakes mounted on the front of boats were used. Vegetation is gathered, pushed toward the shore and lifted by the rake.

Raking Flotage from Breeding Area

Destruction of Adult Mosquitoes. Malaria control operations have been directed principally against the larval stage of the mosquito. However, recent work in India and South America has demonstrated that the spray killing of adult mosquitoes around habitations under certain conditions is an effective means of malaria control. Although this method has little effect on the density of the malaria mosquito population in an area, it does kill mosquitoes that are in the process of becoming infective.



Adult Mosquito Destruction

Among the adult destruction methods, greatest progress has been made in the development of aerosol sprays. Pyrethrum or thiocyanates are mixed with liquid freon and are dispersed by releasing the gas. Release of the gas for four seconds from a standard pyrethrum-freon bomb is sufficient to kill all mosquitoes in a space of 1000 cubic feet.

Adult spraying was used in the Stuttgart area in Arkansas, where an advanced pilot training school is located in the midst of a large rice-growing area. The 2800 acres of breeding area within flight range of the school could have been controlled partially by airplane dusting but the cost per capita would have been prohibitive. Under these circumstances an intensive adult spraying program seemed the most practical approach to malaria control. Each building in the protected area was sprayed twice a week. This gave four or more chances of killing the mosquito between its first blood meal and its final development as a malaria transmitter.

The control area consisted of 19 farm establishments with a total of 119 buildings. A power spray unit mounted on a one-half ton truck was used to spray outbuildings. For interior spraying, the pressure sprayers or hand-operated sprayers were used.

The cost of the program was $1.23 per building application. The cost per square mile for this type of control was approximately the same as the State average for larviciding, $1,070.

IMPORTED MALARIA

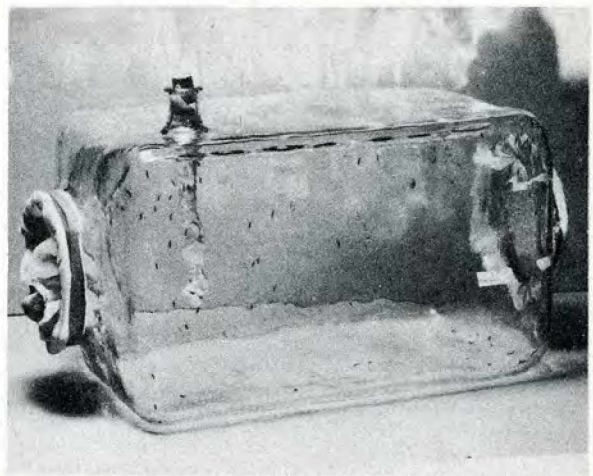
IMPORTED MALARIA STUDIES

The U. S. Army, Navy, and Public Health Service, recognizing that malarias contracted in foreign countries are being brought into this country by soldiers and that relapses are occurring in these soldiers, set up a joint program to study the public health significance of imported malarias. This program is called "Imported Malaria Studies."

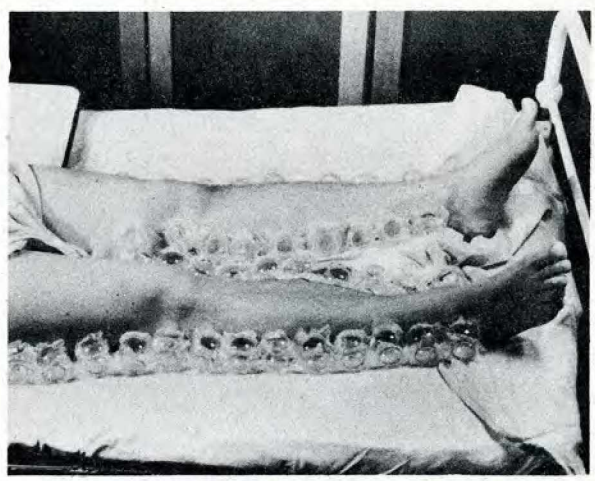
The principal objectives of the program are (1) to determine the ability of the imported malarias to infect American anophelines and to be transmitted by them; (2) to gather information on parasitology and other characteristics, and to distinguish, if possible, between strains; (3) to evaluate the findings and to suggest their implications upon control measures.

The divisions of the Public Health Service which are cooperating in this work are the Office of Malaria Control in War Areas and the National Institute of Health. The Office of Malaria Control in War Areas has made available funds for carrying on the work, and supplies all the personnel with the exception of the Officer in Charge. The National Institute of Health furnishes the Officer in Charge and is responsible for the direction of the investigation. The Army makes available troops relapsing with imported malaria and has provided space for the two branch laboratories.

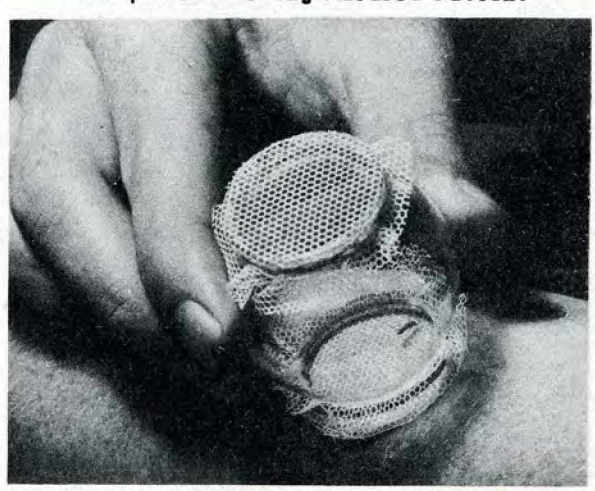
The headquarters laboratory of Imported Malaria Studies is located in the National Institute of Health Malaria Research Laboratory at Columbia, S. C., where the regular personnel and equipment of the Institute are used when needed. This laboratory has access to four Army hospitals and one Navy hospital in North Carolina, South Carolina, and Georgia. The branch laboratories are located at Letterman General Hospital, San Francisco, California, and Harmon General Hospital, Longview, Texas. At each laboratory an insectary is maintained, with *Anopheles quadri-*



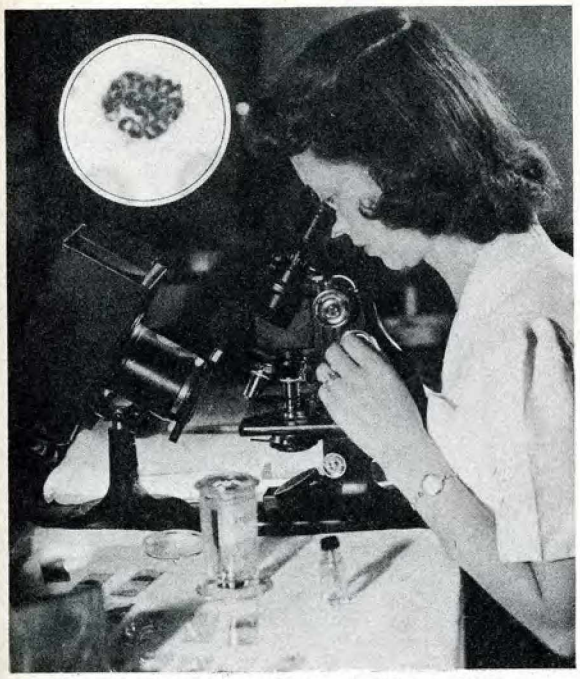
Laboratory Mosquito Colony



Mosquitoes Biting Malaria Patient



Attempting Transmission



Examination for Malaria Parasites

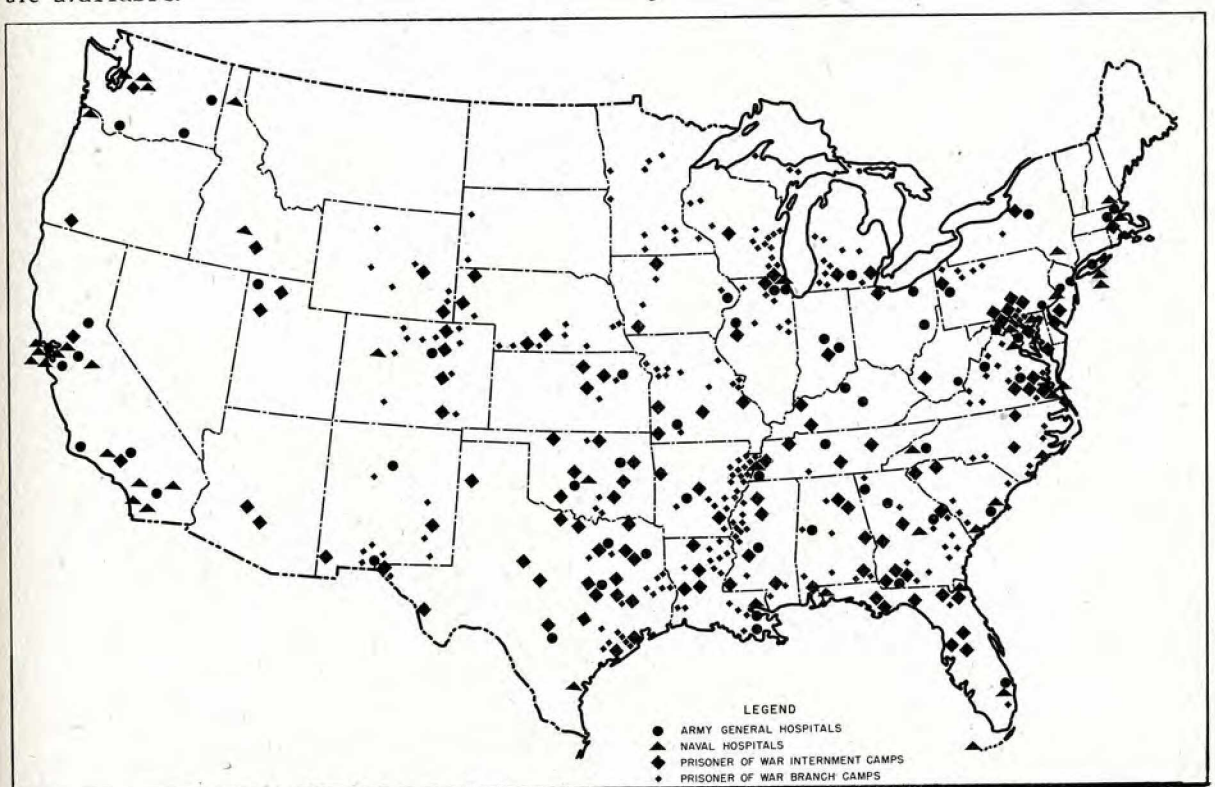
maculatus Say or *Anopheles freeborni* Aitken as the standard testing species. Other suspected species are tested as they are available.

The techniques involved in the work are those which have been worked out during the past few years in the Columbia laboratory. Large colonies of mosquitoes are maintained. At the optimum age, these mosquitoes, preferably about 200, are fed upon the relapsing malaria patients. At regular intervals the mosquitoes are dissected to determine the degree of infection and distinguishing characteristics. Batches of infected mosquitoes are fed upon mental patients who need malaria for therapeutic reasons. This tests the transmission of these strains.

So far over 11,000 mosquitoes have been tested on nearly 100 cases of relapsing imported malaria. The results indicate that these imported malarias are a definite threat to the public health of this country inasmuch as they are transmitted by American anophelines. Studies are under way now to evaluate this hazard.

MOBILE UNITS

As a precaution against imported malaria, eight mobile malaria control and inspection units have been organized. Each



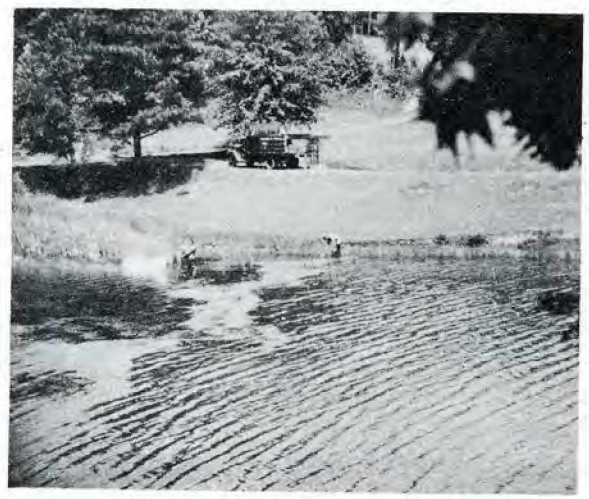
Location of Army and Navy Hospitals and Prisoner-of-War Camps

unit consists of a passenger vehicle and a 1½ ton truck, fully equipped for inspection, larviciding, interior adult mosquito control, and incidental hand drainage work. The officer in charge of the unit has a small crew of two to five men to do the control work and to assist with inspections. The units are assigned to the USPHS district offices to be used where needed and are directly responsible to the district MCWA personnel

The mobile units were designed primarily for malaria control and inspection around prisoner-of-war camps and Army general hospitals in Public Health Service districts outside the malarious belt. Entomological inspections are made around all POW camps and hospitals and control is undertaken when the inspections indicate the necessity. Twenty seven control zones and 37 inspection zones have been established. If the problem in any zone becomes too extensive for adequate control by the mobile unit crew a separate resident control project is set up.

The mobile units are available for immediate service on an explosive epidemic of malaria, irrespective of location with regard to war establishments. It is felt that such localized outbreaks can be stamped out within a short time by concentrated work in the immediate vicinity of the malaria cases.

Equipment Included in Mobile Unit



Mobile Unit Crew at Work

QUARANTINE

It is not enough to stand guard against the importation of new strains of malaria. Malaria of an endemic type is already present in this country and could reach epidemic proportions if new and highly efficient vectors should be imported. Such a condition occurred in northeastern Brazil when *Anopheles gambiae*, one of the most efficient malaria vectors, was accidentally introduced from Africa in 1930 By 1938 northeastern Brazil had become "the scene of epidemic malaria equal in severity if not in extent to that of the worst outbreaks described in the literature of the disease" (Soper and Wilson, 1943). This is a clear warning at a time when world barriers are disappearing. Few mosquitoes were able to overcome the hazards of long sea voyages on surface vessels but the new clipper ships of the air provide ideal transportation for insect hitch-hikers. The unprecedented air travel during the war has increased the chances of importing new disease vectors tremendously. It is likely that more chances of introducing a foreign mosquito now occur in a single month than occurred during preceding centuries.

This threat is being anticipated by rigid quarantine plus constant surveillance in the vicinity of airports of entry in an effort to catch any immigrant disease vector that may have slipped past guards. This work is a function of the Foreign Quarantine Division of the Public Health Service. Seven MCWA entomologists have been assigned to the Quarantine Division to assist during this period of

Passenger Plane Approaching Florida Coast

Precautionary Spraying before Plane Lands

greatly increased hazard. These men are located at Miami, West Palm Beach, New Orleans Brownsville, and Ft. Worth.

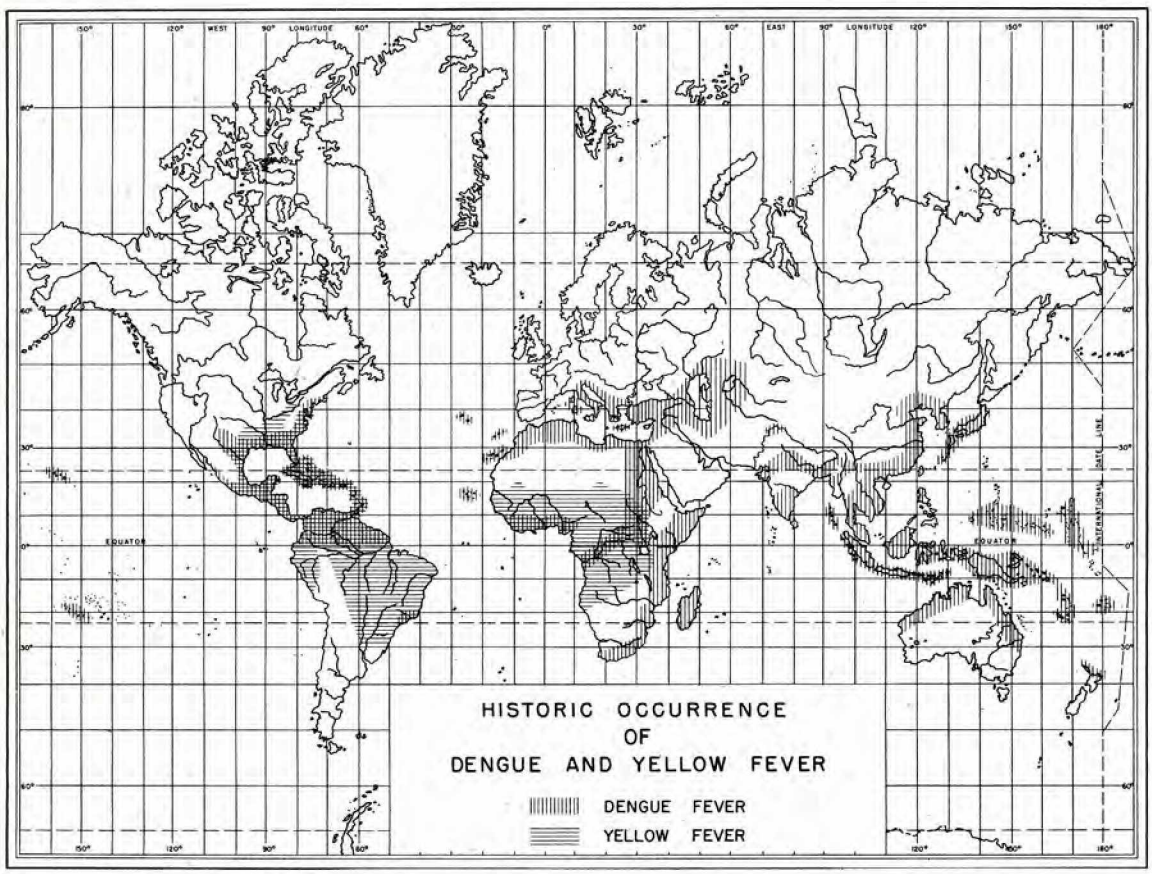
The disinsectization program involves spraying of the planes while in flight by either airline or military personnel and further spraying upon arrival after passengers have disembarked but before the baggage and freight are removed. Following this last spraying a search is made for insects, both dead and alive. During the past year approximately 25,000 insects were recovered from the hundreds of planes inspected. Eleven hundred and five mosquitoes are included in this total of which 30 were tropical anophelines. All of the latter had been killed before recovery.

The recovery of the tropical malaria vector, *Anopheles albimanus*, on two occasions in the vicinity of Florida airports indicates that mosquitoes can and do enter the country in spite of the rigid quarantine. In one case a female *albimanus* was found in a natural resting place adjacent to Morrison Army Air Field at West Palm Beach. The specimen was dead when found and there seems to be no explanation for its presence other than that it arrived by plane. In the other case an Army Sanitary Corps Officer found a single larva of *albimanus* adjacent to the Army airport at Boca Raton, Florida. An exhaustive follow-up failed to reveal further specimens but these two instances show the importance of the surveillance program.

Quarantine Officer Checking Temperatures

Searching Plane for Mosquitoes

DENGUE - YELLOW FEVER MOSQUITO CONTROL



Yellow fever was once the scourge of two continents. Deeply rooted in the tropics, it invaded temperate cities in the United States during the humid, hot summers. Seldom did a year pass without an epidemic in one or more southern cities. New Orleans, Memphis, Mobile, Savannah, Charleston, and even New York and Philadelphia were visited on several occasions. Since Walter Reed's dramatic mosquito transmission experiments at the turn of the century, there has been a steady increase in knowledge and decrease in incidence of the disease. Greatest achievements of the past half century are the development of a technique for eradication of the mosquito vector and the development of an effective vaccine. Greatest disappointment is the discovery of endemic yellow fever in the monkeys of South American and African jungles. Greatest threat for the future is the vast expansion of air travel, which transcends all barriers and brings South American jungles within a few hours flying time of door steps in the United States.

Less spectacular, but more imminent, dengue or "break-bone" fever has already struck in the Pacific and could paralyze southern cities now, when we can least afford it. Although not fatal, dengue is a painful, debilitating disease and is especially dangerous to a country at war because of its explosive potentialities. Cases were counted in thousands in Florida during the 1930's and in hundreds of thousands in Texas during the 1920's.

To meet these threats the United States Public Health Service conducted surveys prior to the war, and since 1941

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it has operated an emergency program for the control of the mosquito vectors. As a division of the Office of Malaria Control in War Areas, this work is conducted through State and local health departments.

The job is so overwhelming that a new concept of control has been required to fit conditions in the United States. In South America, before the war, eradication was found to be cheaper than control. A large initial expenditure of funds and manpower proved to cost less in the long run than a less expensive but continuous program. It would be unjustifiable at this time to divert sufficient manpower from war activities to eradicate dengue-yellow fever mosquitoes from the principal

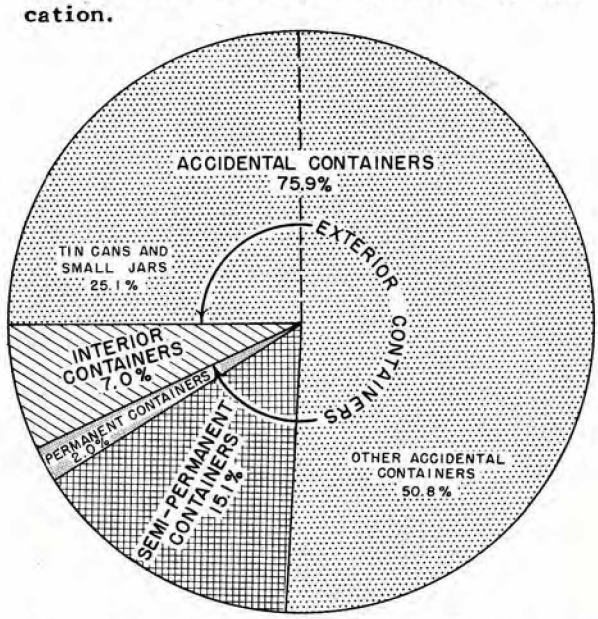
Aedes aegypti (Linn.)

cities of the southern United States. In place of eradication, a comprehensive program of mosquito control in critical cities where military installations and war industries create the greatest hazards is offered; together with disinsectization of planes in cooperation with the Foreign Quarantine Division of the Public Health Service; vaccination of air passengers and ground crews in cooperation with the Army, Navy, and Rockefeller Foundation; notification of air passengers; and an epidemic program prepared for action on 24-hour notice.

DENGUE-YELLOW FEVER VECTORS

The principal vector of dengue and yellow fever throughout the world is *Aedes aegypti* (Linn). A closely related mosquito, *Aedes albopictus* (Skuse), is important in Hawaii and the Orient, and *Aedes scutellaris* (Walker) is dominant in the South Pacific. Although less susceptible to eradication measures, *albopictus* and *scutellaris* may be considered as similar to *aegypti* for all practical control purposes.

Experience with malaria shows that the habits of a mosquito species are most critical in determining its importance as a disease vector. *Aedes aegypti* has the most domesticated habits of all mosquitoes. In fact, it seems to be inseparably associated with mankind, preferring to feed on human blood, breed in man-made containers, and live in cities. Larvae have been found thriving in an inverted bottle cap, half an egg shell, an old shoe, and in the shallow well of a sticker-tape machine on the counter of a downtown store. More typical breeding places are temporary or permanent water containers in and around houses. Seventy-six per cent of the containers found breeding during the summer season of 1943 were receptacles such as tin cans, bottles, old tires and other typical components of a junk pile. Twenty-five per cent of the breeding was in tin cans alone. This is no great technical problem, but a problem of individual and municipal sanitation prompted by education.



Percentage of Types of Breeding Containers

AEDES AEGYPTI INSPECTIONS

The *Aedes aegypti* inspector in a project city is a combination of door-to-door salesman, super mosquito sleuth, and efficient mosquito control operator. His is the job of selling himself and the project to a housewife who may be busy or unsympathetic, and at the same time inspecting every nook and cranny of the premises for possible mosquito breeding places. Breeding places are corrected by eliminating containers or by larvicidal treatment.

It is recognized that constant repetition and careful checking are necessary in this type of work. In fact, routine eradication procedure calls for a 10-day inspection cycle, so that each premise is visited within the period of development of a generation of mosquitoes. This exhaustive approach to *aegypti* control was tried on the Key West project as a demonstration and training program, but is neither possible nor desirable for the rest of the projects, considering the critical manpower shortage.

Objectives of the *Aedes aegypti* control program are: (1) reduction of the mosquito vectors of dengue and yellow fever below the danger point; (2) training of personnel for possible epidemics; and (3) education of householders to be their own inspectors so that they can carry on mosquito control after our emergency program is over.

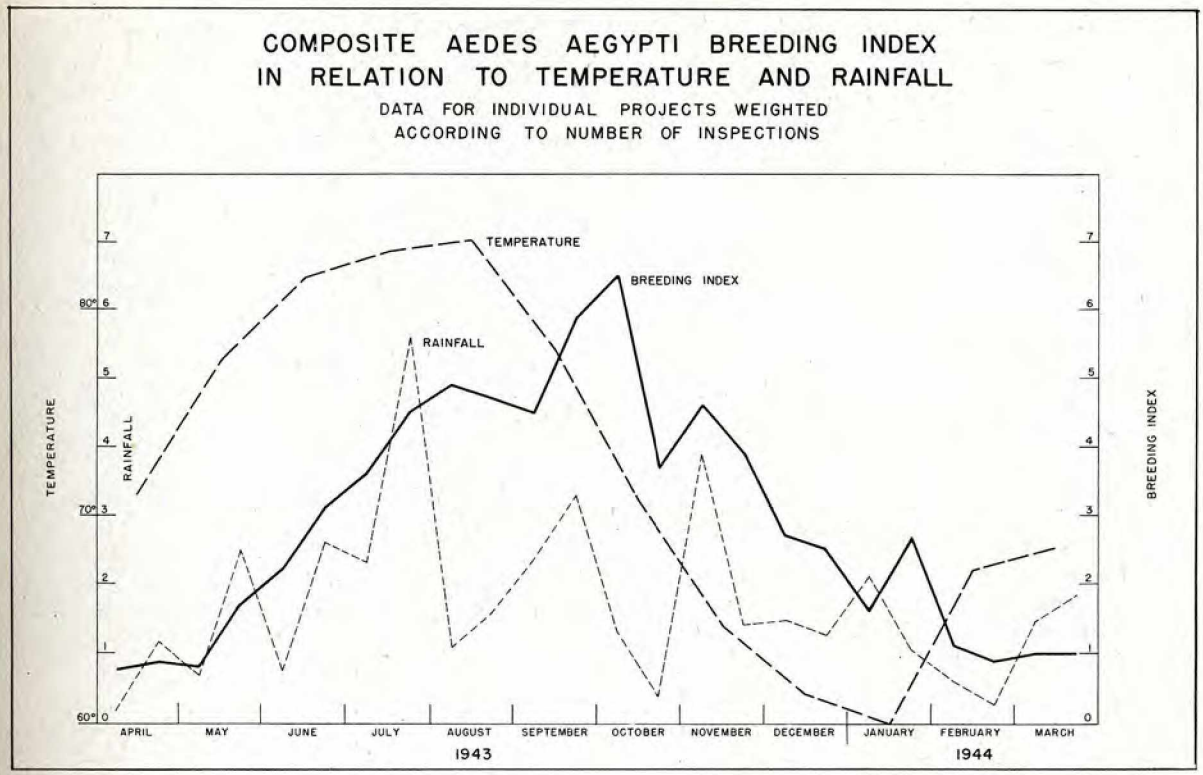
Results of most *aegypti* control projects are now available for a complete breeding season and winter season. These results are as varied as the cities and the people of the various sections of the country. Projects have been deliberately made more or less autonomous, headquarters supervision being restricted to technical advice, suggestions as to policy, and advice on procedure. Detailed operations must be made to fit the local situation. For example, Key West has many abandoned cisterns which are bad permanent breeders; Honolulu has no cisterns but has many tropical garden plants that hold water and breed mosquitoes. Cities vary in their racial composition, and each race presents special problems to the mosquito inspector. The Negroes of the Southeast leave three tin cans in the back yard as a foundation for their laundry kettle, the Cubans in southern Florida hide their house plants from the inspector, the Mexicans in Texas store water for drinking purposes, and the Japanese in Honolulu raise tropical plants with cup-like leaves that hold water.

Destroying Abandoned Cistern

***Aegypti* Breeding in House Plant**

THE *AEGYPTI* BREEDING INDEX

The only universal criterion of *aegypti* control is the "breeding index". Recognizing that this ratio of premises found breeding to total premises inspected obscures local concentrations of breeding and ignores the number of containers found breeding and the number of larvae per con-



tainer, it remains our best general measure of *aegypti* occurrence in a city. In temperate regions, this index follows the temperature curve with a lag of a month or two. Incidental dips and peaks follow fluctuations in rainfall. When results of all projects in the continental United States are combined and plotted with temperature and rainfall data, it becomes evident that the breeding index continues to rise cumulatively until cool weather slows down the breeding, and until frosts kill all adults outside. During the first full year of operations the average index for all projects reached 6.5%. Before control programs were completely established, initial indexes for Key West were 30%, for Galveston 35%, for Houston 20%, for Brownsville 38%, and for Savannah 34%. During the winter in Savannah and Charleston and more northern cities, breeding continues in protected places such as ivy bowls inside houses, and fire buckets and barrels inside warehouses, but the index is low. Eggs remaining outside in bottles, cans, and other trash, are a source of breeding for the next season.

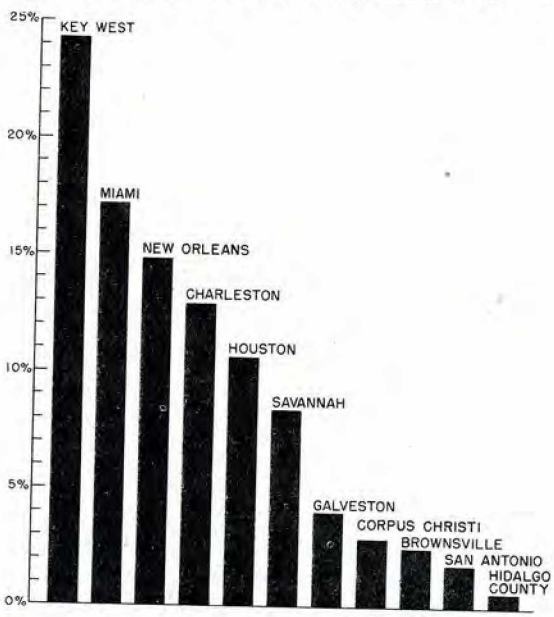
Henry Rose Carter suggested an *aegypti* breeding index of 5% as the threshold of sanitary importance. This is admittedly an abstract figure because a 5% index in a particular zone in a city would make disease transmission possible. In fact, a single infected mosquito can cause a great deal of trouble, regardless of the index. Furthermore, the index is a nebulous figure, dependent upon the efficiency of the inspectors, and the threshold of sanitary importance varies according to the number of immune people, the number of persons sick with dengue or yellow fever and exposed to mosquitoes during the three-day infective period, and the number of adult mosquitoes in the immediate vicinity of these cases. Under the circumstances, it is useless to set a definite index as an objective in our anti-aegypti campaign. Nevertheless, it is clear that reduction in mosquito breeding results in fewer adult mosquitoes and therefore less chance for disease transmission. Finally, we reach a level at which mosquitoes are so few that they do not encounter a sick person during the three-day infective period. At this point the disease dies out.

EVALUATION OF RESULTS

Results of individual *aegypti* projects defy comparative analysis. Differences in breeding indexes are often less than the error that would normally be expected under such conditions. However, relative size of the projects in relation to the total population gives some indication of the scope of the work.

Key West, with a population of 13,000 people, is out of line because it was operated with a different objective than the other projects. In general it is felt that one inspector per 1,000 population is necessary for complete 10-day cycle coverage although Honolulu is being covered with one inspector per 4,000 population. Such coverage was not even approximated in our program outside of Key West and Honolulu, the over-all average being one inspector to 13,500 population.

The average number of inspections per man-day is an indication of the type of *aegypti* program. However, progress will be slower in the early stages of clean-up, and the number of inspections per man-day is really only significant during the summer season, other activities dominating the picture in some projects during the winter months. Individual projects varied in average number of inspections per man-day from 28 in Savannah to 123 in Corpus Christi.



Distribution of Man-Hours

Spraying Elevator Shaft

Differences in stage of the control work are not sufficient to explain this disproportionate rate of routine inspection. The real explanation lies in the philosophy of operations and in the relative importance attached to inspectional, supervisory, service, and educational activities. A breakdown of these data shows New Orleans with the highest and Key West with the lowest proportion of man-hours devoted to routine premise inspections, and Savannah with the most, and Key West with no time at all devoted to special educational activities.

The principles and practice of *aegypti* control were worked out under tropical conditions in close proximity to monkey reservoirs of jungle yellow fever in Africa and South America. Under such conditions eradication proved to be cheaper than control. In the temperate zone cities of the United States it has been found that spectacular control is possible with a minimum expenditure of men and materials. This has been accomplished by three methods in addition to routine inspection of premises. First, project cities are searched for hidden breeding places, the so-called "mother foci" or

permanent protected breeding places from which infestation spreads when conditions are favorable outside. Second, the cold weather of the winter which kills all adult mosquitoes outside is used as an ally. During the winter months emphasis is placed on interior inspections and elimination of mother foci as well as on city clean-up to eliminate cans and bottles containing over-wintering eggs. Third, education is stressed as an integral part of the control program. Quite apart from the long term effect, the value of education can be measured today in man-hours saved. Our limited preventive campaign can accomplish reduction of *aegypti* densities to a safe level only by the fullest cooperation of an informed public.

SPECIAL EDUCATIONAL ACTIVITIES

It is felt that *aegypti* education can best be put over by the inspector during his routine examination of premises. The personal approach and actual demonstration of control methods is ideal. On the other hand, Hidalgo County, Texas with a population of over 100,000, reported that two men reduced the breeding index by 85% from June 1943 to June 1944, by stressing educational measures rather than routine inspection.

An all-out educational campaign was conducted in San Antonio in 1944 under the leadership of the Director of the Health Department assisted by several outstanding

San Antonio Conference on *aegypti* Control

Demonstrating *aegypti* Control to Housewife

authorities on *aegypti* control. This intense campaign reduced the *aegypti* breeding by 78% at a time when it would normally have been expected to increase steadily. Success was attributed in large measure to the complete cooperation of civic school, and medical authorities.

Outside of project cities, educational measures are our only method of attack. For this purpose a mobile unit was outfitted with window displays, leaflets, specialized training films, and other educational material. Working through the Office of Civilian Defense, leaflets were distributed and personal contacts were made with more than 600,000 homes representing close to 2,000,000 persons. The work was started at Miami, Florida and moved along the Gulf and Atlantic Coasts as the breeding season developed.

The program in Brunswick, Georgia from May 5 to 12, 1944 may be taken as an example of the OCD campaign. The breeding index was determined as 10% by a crew of 8 inspectors borrowed from the nearby Savannah project. The mayor issued a proclamation which summed up the dengue - yellow fever problem and called on the citizens

to cooperate through individual cont
work. Health department personnel were instructed in *aegypti* control. Air raid wardens received special training after which they distributed 10,000 leaflets to homes within their precincts and zones. Eight thousand school children were contacted with films, talks, and demonstrations. Addresses were made before civic clubs and to two shifts of shipyard workers. In addition, the general public was reached by means of three billboard displays, movie trailers, daily radio forums, newscasts and spot announcements, and by newspaper articles.

Under epidemic conditions this all-out approach in cooperation with the Office of Civilian Defense could be greatly expanded and the individuals already contacted could serve in a voluntary capacity with a real knowledge and background of anti-aegypti methods.

EPIDEMIC CONTROL

The United States Public Health Service is prepared to assist State and local health departments in the event of a dengue or yellow fever out-break. Facilities are available for an intensive campaign to sterilize the area around a primary case of yellow fever or for a long term siege against a well-established dengue epidemic. Trained men have been assigned to particular jobs, equipment has been set aside for the emergency, and sufficient yellow fever vaccine is available through the National Institute of Health and the Rockefeller Foundation to immunize the entire population of a city. Any or all of these facilities could converge on a given spot in the Southeastern States within a few hours.

The organization has been set up in great detail to cover all possible contingencies, because we cannot anticipate which services will be required in any one instance. In general, it is recognized that two phases or types of operations will be necessary. In the case of yellow fever, an exhaustive local campaign must be started within a very few hours after diagnosis of the first case. Adult spraying around the scene of the case and vaccination of people in the neighborhood will dominate the first day's work. If successful, there should not be any secondary cases.

OCD Warden Distributing Anti-aegypti Notes

Dengue is a different problem. Difficult to diagnose and without a vaccine, the chances are very great that a city-wide epidemic would be under way before effective control measures could be started. Under these conditions, or in case yellow fever gets out of hand, a general *aegypti* control program will be necessary. Routine inspection and correction of breeding places would have to be established on a 10-day cycle.

It may be argued that dengue is not a fatal disease and that it does not justify such drastic measures. This might be true in peacetime, but it is far from true in our critically important southern cities during wartime. Individually, dengue is not serious; but collectively it can prostrate a city. Literally everyone gets dengue if it is allowed to run its course. Shipyards would be closed, and troops would be restricted or immobilized.

DENGUE CONTROL IN THE HAWAIIAN ISLANDS

Two cases of dengue fever were reported from Honolulu during the week ending July 6, 1943. Presumably the disease was introduced through air travel from the South Pacific. Previous epidemics occurred in 1903 and in 1912 and resulted in widespread suffering and general involvement of the entire population. It was imperative that an explosive epidemic be avoided at this time because of crucial military operations based upon the Hawaiian Islands.

The Territorial Board of Health and the Army Medical Department took immediate action to control the mosquito vectors *Aedes aegypti* (Linn.) and its oriental relative, the equally domesticated *Aedes albopictus* (Skuse). In spite of the efforts of 24 inspectors employed through Chamber of Commerce funds and five soldiers working as a crew to inspect the city section by section and in spite of an educational program through the press, radio, and Office of Civilian Defense, dengue increased. Cases became so numerous that Waikiki was declared off-limits for military personnel on August 8. This directive attracted international attention.

Strenuous measures were necessary to clean up this important commercial and recreational area so an all-out program was inaugurated to destroy infected adult mosquitoes. All premises in the Waikiki area were sprayed inside and out, utilizing undiluted commercial insecticide applied by high pressure Chemical Warfare decontamination truck sprayers.

DENGUE CONTROL BY THE PUBLIC HEALTH SERVICE

Late in August assistance was requested of the United States Public Health Service. The officer in charge of the *Aedes aegypti* Section of MCWA and the supervisor of the Savannah *Aedes aegypti* control unit were immediately sent to Honolulu to organize a control program.

Army Signal Corps Photo

Interview Prior to Premise Inspection

Because of wartime restrictions on transportation of personnel and equipment it was necessary to build up an entire program from the nucleus of inspectors already on the job. The greatest problem was to quickly assemble, outfit and train enough inspectors to cover the City of Honolulu on a 10-day cycle. However, a combination of good luck and hard work made it possible to put 96 men, completely equipped, in the field on September 15. This would have been difficult in most mainland areas, but standard equipment or suitable substitutes were found by diligent search in supply houses in Honolulu. Inspectors were assembled by a hiring campaign which netted only 13 men, plus 33 men already working on the program, plus 50 detached service soldiers supplied through the Office of the Surgeon,

Crew of Dengue Mosquito Control Inspectors

Central Pacific Area.

The original intention was to release military personnel as the emergency subsided and as civilian labor was hired. However, the manpower shortage was so acute that additional soldiers had to be added as the disease spread to rural Oahu and the outside islands, and as dengue cases were imported in increasing numbers from the South Pacific. By the end of the fiscal year the entire organization numbered 150 men in Honolulu, 75 men elsewhere on Oahu, 74 men on the island of Hawaii, 43 men on Maui, and 42 men on Kauai. Personnel on the outside islands consisted of 2 colored sanitary companies, each with 114 enlisted men and 3 officers.

Control followed the standard inspection-correction technique, but special problems were encountered here as in every city. Water standing at the bases of leaves of ape plants and in the leaf cups of pineapple lilies was particularly troublesome because these are the commonest ornamental plants in the gardens of Honolulu. *Aedes albopictus* was especially prone to breed in such places and in tree holes and was found breeding from the center of the city up to an elevation of 2000 feet in the forest.

Mosquito control was closely correlated with epidemiological findings. Confirmed cases of dengue were reported daily and a crew of "trouble shooters" was sent out to spray and inspect the disease premises and the area immediately surrounding these spots. A Public Health Nurse visited each dengue patient and set up a bed net to prevent the patient from infecting additional mosquitoes. A case history was obtained to assist in tracing the source of infection.

As was expected, a time lag occurred between the start of expanded control activities and the first noticeable decrease in dengue cases. During this interim, a second major focus of infection developed in the congested Kakaako section adjacent to the business district near the center of the city. A prominent laundry in this district failed to cooperate in killing adult mosquitoes after breeding had been stopped. Many cases were traced to this source and the situation reached a climax

when 70 employees of the laundry were down with dengue at one time.

This and subsequent disease foci were treated like Waikiki except that a more efficient and less caustic pyrethrum-base water-diluted spray was used in the 400 gallon decontamination spray rigs. Other special activities included clean-up of thousands of loads of tin cans, bottles, and other breeding containers, spraying of catch basins, clearing of roof gutters, stocking of ponds with mosquito fish and filling of rock and tree holes.

Educational activities were vital to the program because reduction in mosquito breeding depended upon elimination of breeding places in and around the home and eradication of the disease depended upon prompt reporting of cases. Every available means of contacting the public was utilized and the publicity was multiplied many times by inclusion in commercial advertisements. Since three-fourths of the population is of foreign ancestry, publicity was issued in the Japanese, Chinese, and Korean languages.

The city-wide breeding index continues to prove useful for over-all supervision of the work but has the same disadvantages in Honolulu as elsewhere. Rainfall, in particular, confuses the picture because such dry sections of the city as Waikiki have as little as 20 inches of rain per year; whereas the residential sections near

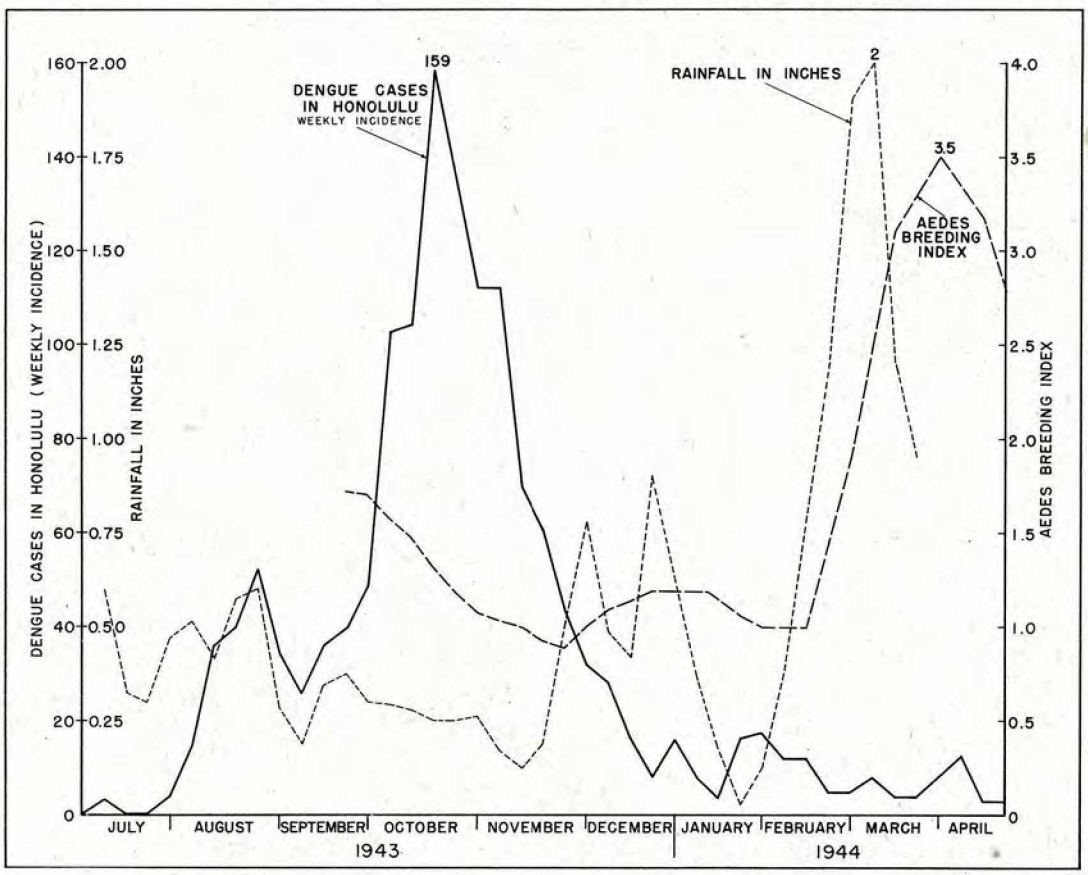
Army Decontamination Sprayers in Use

Cleaning Clogged Roof Gutter

Treating Water in Spider Lilies

Killing Larvae in Tree Hole with Kerosene

the heads of Nuuanu and Manoa Valleys have over 100 inches of rainfall. As might be expected, mosquito breeding was closely correlated with rainfall but surprisingly the highest concentrations of dengue cases did not coincide with the zones where mosquitoes were most abundant. Dengue flourished under congested conditions in the dry Kakaako District where houses are unscreened whereas it was self-limited in the presence of screened homes with large gardens and extensive grounds in the wet, mosquito-ridden heads of the valleys.



Trend of Dengue Cases Compared with Rainfall and *Aedes* Breeding Index

RESULTS OF DENGUE CONTROL

The proof of any control program is measured by the results obtained. The Hawaiian dengue epidemic started in July from two cases and built up to a maximum of 159 cases during the third week in October. Immediately after the peak, a marked reduction took place, with the decrease occurring as rapidly as the earlier rise. In January 1944, the number of new cases appearing each week began to level off below 20 and by June, 1944, the average had dropped to less than one new case per week.

Prospects for the future are difficult to analyze. The commonest vector, *Aedes albopictus*, breeds throughout the dense forests up to 2000 feet, as well as in the cities, so elimination of this vector from the entire territory is impossible. On the other hand, it has already been shown that breeding can be reduced to a satisfactory level wherever sufficient effort is devoted to the job. Dengue has not only been held within bounds, it has actually been reduced to a small number of cases per week. Final elimination of the disease depends upon continued effort and prompt reporting and follow up of cases. Reintroduction is very possible because of dengue cases returning from the South Pacific, so constant vigilance and a thorough routine mosquito control program will be necessary for the duration of the war.

OTHER MOSQUITO-BORNE DISEASES AND INSECT PESTS

OBNOXIOUS MOSQUITOES

Health officials for years have been preoccupied with the anopheline vectors of malaria and the aedine vectors of dengue and yellow fever. All other mosquitoes were classified disparagingly as "pest mosquitoes." The original MCWA budget specifically limited MCWA expenditures to the vectors of malaria, and later included a small fund for the control of dengue and yellow fever vectors. This was a sound policy considering the funds and manpower available for mosquito control. However the public tends to judge the effectiveness of the program not in terms of malaria control, but in terms of mosquito bites so area supervisors have been hard put to explain to irate citizens the mass emergences of gallinippers or flights of salt-marsh mosquitoes.

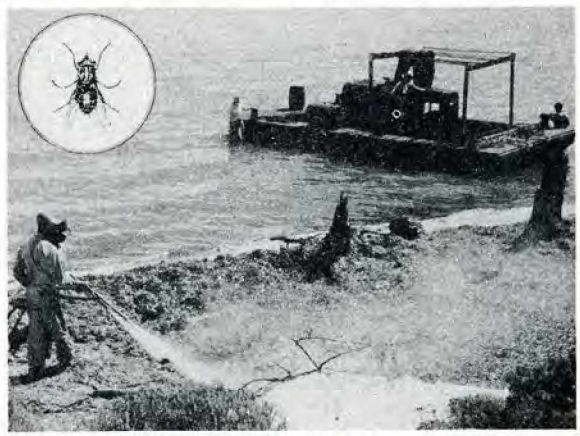
Mosquitoes can and do become extremely annoying, even to the point where vital war work or troop maneuvers are affected. MCWA is now authorized to survey and even to control pest mosquitoes upon specific request of the Army, but this work is contingent upon reimbursement by the requesting agency and is limited to a few cases of major military importance. Surveys have been made in Pennsylvania, New Jersey and Mississippi, and control has been started in a New Jersey area.

DOG FLY CONTROL

The dog fly, *Stomoxys calcitrans* (Linn.), is a serious hindrance to military personnel along the Gulf coast of northwestern Florida. MCWA is continuing to support dog fly control work of the Bureau of Entomology and Plant Quarantine. Breeding occurs in beach deposits of marine grasses, so the windrows are sprayed with creosote.

MOSQUITOES THAT TRANSMIT DISEASES

Studies on the role of mosquitoes in the transmission of diseases other than malaria, dengue, and yellow fever, and wartime experiences in the South Pacific suggest that the time has come to reexamine the concept of "pest mosquitoes." It now appears that many of our commonest mosquitoes are capable of carrying diseases. Accepting this conclusion we are at once confronted with a general anti-mosquito campaign. Several projects of this kind have been highly effective in the United States, and the increased interest and importance of mosquito-borne diseases during the present war should stimulate many communities to establish all-out mosquito control programs



Spraying Dog Fly Breeding Places

ENCEPHALITIS

The Western Equine and St. Louis types of encephalitis have caused several epidemics in this country. They have been transmitted experimentally by the following mosquitoes: *Culex tarsalis, Culex coronator, Culex pipiens, Aedes lateralis, Aedes taeniorhynchus, Aedes vexans Culiseta inornata, Culiseta incidens* and *Anopheles freeborni*. Fortunately, encephalitis has not broken out in epidemic form thus far during the war.

FILARIASIS

Filariasis has recently skyrocketed to prominence and may be of great post-war concern. It is a disease caused by the nematode worms, *Wuchereria bancrofti* and *Wuchereria malayi*. The adult worms occur in the lymph glands and tissues. They re-

lease small worms known as microfilariae which circulate in the outer blood where they are readily accessible to biting mosquitoes. Some microfilariae circulate in the outer blood periodically either during the daytime or at night while others show no such regularity. A definite relationship exists between the biting habits of the mosquito vectors and the time when the microfilariae circulate in the blood.

Unlike the malaria parasites, filaria worms do not multiply in the mosquito. They undergo larval development in the thoracic muscles and infective forms migrate to the proboscis sheath rather than to the salivary glands. From the proboscis sheath they emerge and burrow through the skin of the mosquito's victim.

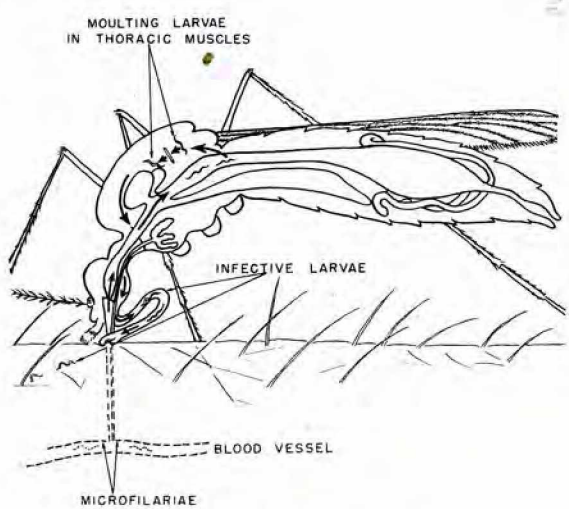
During the incubation period of 12 to 18 months, the worms migrate all over the body but especially to the region of the groin. They cause transient inflammation and swelling of the lymph glands. Elephantiasis of the scrotum and extremities only occurs after repeated infections and long exposure. No specific treatment is known for filariasis and no satisfactory method of freeing the blood stream of microfilariae has been discovered.

In the South Pacific, filariasis is second in importance only to malaria. Only a few cases showing microfilariae in the peripheral blood stream have been reported. So far the most serious effects of filariasis have been psychological. Victims of this disease fear the possibilities of advanced elephantiasis of the extremities and scrotum. However, there seems to be no danger of this if patients are moved out of endemic areas soon after the disease is diagnosed.

Filariasis is endemic in the Caribbean region. It has been introduced into this country by Puerto Ricans and by Negro immigrants from the Virgin Islands. Thirty years ago an endemic focus of filariasis, presumably established following the introduction of the disease in Negro slaves from Africa, existed around Charleston, South Carolina. Since that time this focus has apparently died out.

An important question at the moment is which of our United States mosquitoes are capable of carrying this disease. It is known that the common *Culex quinquefasciatus* is a potent vector. Other so-called pest mosquitoes are known to develop infective larvae The National Institute of Health is now conducting transmission studies and research on diagnostic tests and chemotherapy of filariasis.

Filariasis stands today as the greatest public health enigma of World War II. A certain number of filariasis carriers will no doubt be distributed over the country following the war. If a sufficient number of these should be concentrated in areas where effective mosquito vectors are prevalent, it is conceivable that endemic foci of filariasis might become re-established in the United States. MCWA has designated a medical officer to keep abreast of the latest developments in this field and to provide popular and technical information on the subject. A summary of the distribution and density of all mosquitoes in the United States is maintained and is available to military authorities and others on request. This information is a by-product of routine entomological inspection and surveillance for malaria, so no extra field work is involved. The potentialities of the filariasis situation warrant alertness: and the present policy of keeping informed, supporting research, and watchful waiting appears to be a sound procedure.



Diagrammatic Filariasis Cycle

IN-SERVICE TRAINING

Entomological Inspection at Field Training Area

The most critical shortage during wartime is not materials but manpower. MCWA, as an emergency program, started with only a nucelus of trained men. As the activities and responsibilities of the organization increased, it was necessary to enlist the services of additional doctors, entomologists, and engineers, despite the diminishing number of men available in these professions. This growth was facilitated by an orientation and training program designed to teach fundamentals of malariology to men trained in related fields, such as civil engineering, general entomology, biology, and general medicine.

Well-trained professional personnel are vital to the program because they, in turn, train sub-professional employees - inspectors and foremen - on individual projects. Herein lies the success or failure of the entire program. If inspectors and foremen are properly instructed, satisfactory results will be obtained; if their training has been neglected, the effectiveness of the program will be diminished.

The in-service training classes are conducted by experienced entomological, medical, and engineering officers. Every phase of the program is discussed, and lectures are supplemented by educational film strips, laboratory work, and directed reading. The program includes a period of field training which is most valuable to the trainees. Practice work is carried on at a specially selected training area near Atlanta. Here the trainee himself carries out the steps necessary in establishing and conducting an inspection and control program. Through the courtesy and cooperation of the Georgia Department of Public Health, the trainees visit Valdosta, Ga., where they study a malaria control area in actual operation. *Aegypti* control is studied at the Savannah, Ga. project.

A summary of administrative procedures, along with information on the organization, customs, and history of the Public Health Service are given each class of trainees. Newly commissioned officers are instructed in military courtesies, and the relationship of the Public Health Service to other uniformed services.

Since December, 1943, 49 trainees have completed the course. Sixteen of these were entomologists, 25 engineers, 3 surgeons, and 5 biologists in other specialized fields. Twenty-eight of the 49 trainees had had no previous experience with the Public Health Service. In addition to these, 12 Public Health Service officers attended selected portions of the course. Four of these attended the course as partial preparation for duties with the United Nations Relief and Rehabilitation Administration. The Division of Health and Sanitation of the Coordinator of Inter-American Affairs sent a Fellow from Panama to the In-Service Training course in connection with his field study of various MCWA projects. Several visitors from other services have attended portions of the course.

Results of the In-Service Training program have more than repaid the efforts that have gone into its organization. Field work has been more intelligently planned and executed, officers have had a better understanding of their duties and their relationship to the headquarters office, and reports have been more complete.

Area Supervisor Explaining Dynamited Ditch

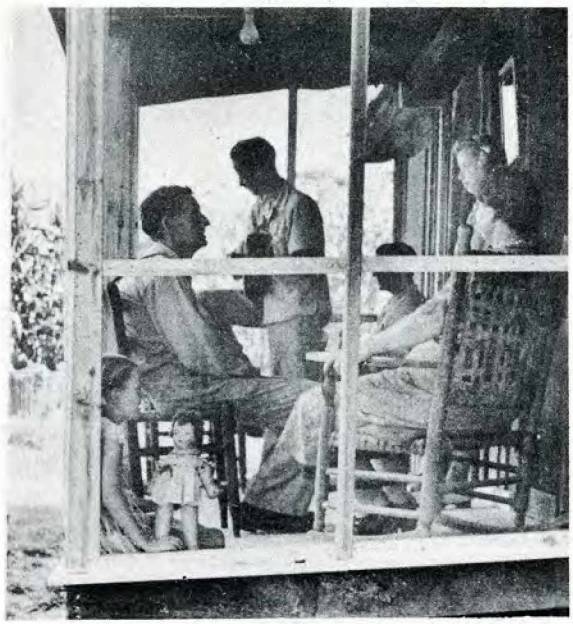
Anopheline Identification

Study of Malaria Parasites

Adjusting Nozzle on Knapsack Sprayer

EDUCATION

Unscreened Houses Invite Mosquitoes



Screens Protect Families from Malaria

The effect of education on the incidence of mosquito-borne diseases is indirect but positive. General malaria awareness has been an important factor in the recession of this disease in the United States.

The perpetuation of preventable diseases depends largely on the habits of people. For example, the transmission of hookworm depends on the habit of depositing human feces on the ground in easy access to people in the habit of walking with bare feet. If either of these habits is altered the disease ceases to be transmitted. This is exactly what has happened over a large part of the country during the last few decades.

The transmission of mosquito-borne diseases is more complicated. Here the habits of both mosquito and man must be considered if the disease is to be prevented. There are no known methods for changing the habits of the mosquito. The habits of man can be changed through education.

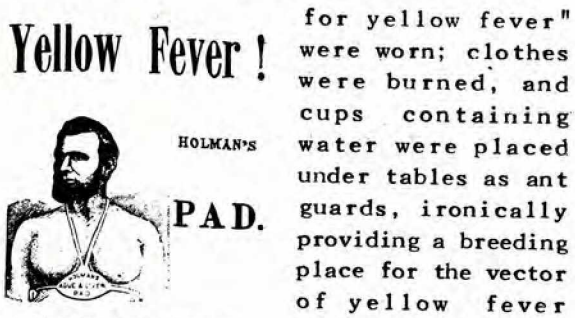
Malaria would disappear from the Southeastern United States within a few years if man would alter his behavior only slightly. It is stated by eminent malariologists that most malaria is man-made; all malaria is man-tolerated. It is largely a by-product of construction without regard to disease prevention.

The habit of building artificial impoundments without taking proper precautions to prevent anopheline breeding; the habit of building roads which impound water because culverts are not properly placed; the habit of making improperly drained borrow pits for road construction or other use; the habit of sleeping in unscreened houses or sitting around in the evening without protection from mosquitoes; these and other habits are responsible for man's malaria. It is generally conceded that malaria could be eliminated from the United States if everyone protected himself from mosquito bites.

The danger of dengue and yellow fever in this country exists solely because of man's habit of providing artificial breeding containers for the *Aedes aegypti* mosquito. Being a purely domestic mosquito it could be eradicated in a very short time if everyone kept his home and premises free of mosquito breeding

INFORMATION AND ACTIVATION

The prevention and control of mosquito-borne diseases through education resolves itself into two components: information and activation. Both are necessary. People can become activated and yet waste time and energy in an unsuccessful attempt to control a disease because they are lacking in correct information. During the yellow fever epidemics in this country people were activated by the horrible devastation of this disease but, lacking correct information on its prevention, they not only failed to control the disease but in many instances created greater disease hazards. Moss which was thought to harbor the disease was pulled from trees; chest pads advertised as "positive preventives for yellow fever" were worn; clothes were burned, and cups containing water were placed under tables as ant guards, ironically providing a breeding place for the vector of yellow fever within the home of people stricken with the disease.



Newspaper Advertisement, 1876

Activation without information is tragic but can be corrected rather easily, whereas information without activation is more difficult to overcome. The task of activating people is greater than the task of informing them. This is particularly true in the case of malaria because it is a disease which transforms the inherent inertia of mankind into apathy. Fortunately this is not the impasse that it appears to be--we work on a percentage basis in dealing with human beings.

Given the facts about malaria a small percentage of people will not only apply preventive practices themselves but will actively campaign for community control measures. Others will apply individual control measures and will give community enterprises their active support. Many will be indifferent, and a few may be antagonistic. It is the large segment of indifferent individuals that must be informed and activated if mosquito-borne diseases are to be controlled or prevented.

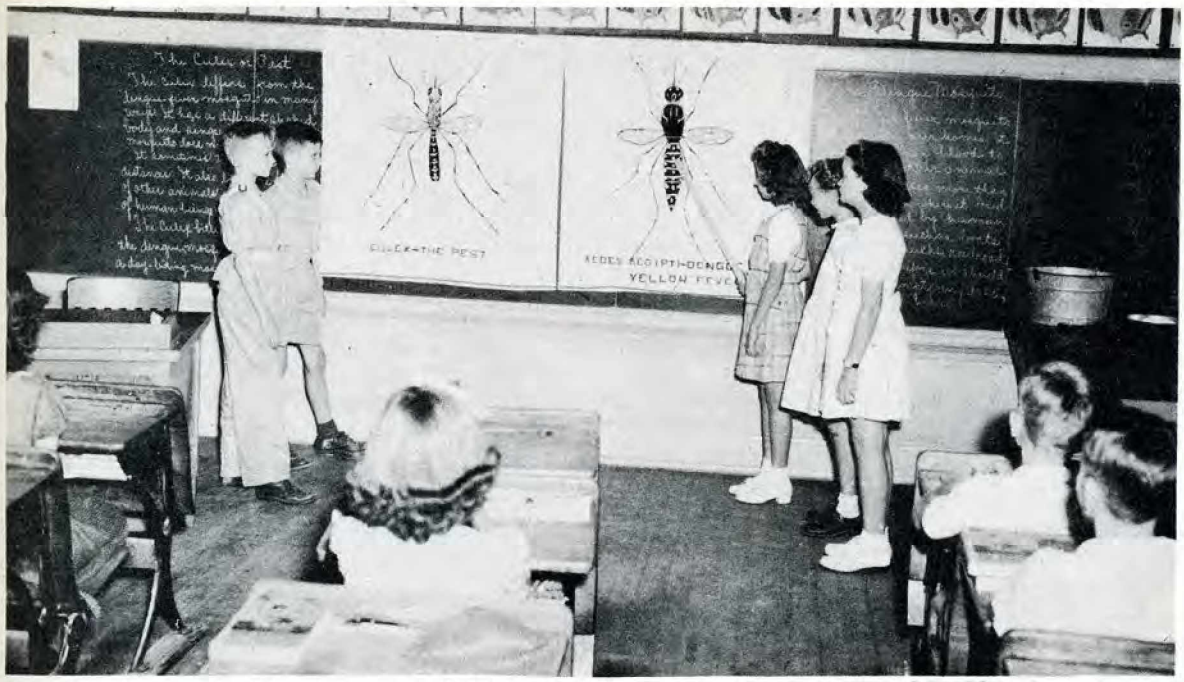
The objectives of our educational work are:

1. To present clearly the facts about mosquito-borne diseases.
2. To state specifically what the individual and community can do to control or prevent mosquito-borne diseases.
3. To stimulate individuals and communities to assume responsibility and to take the necessary action to prevent these diseases.

The most obvious place to carry on a program of health education is in the schools. This long term approach is sound because it gives correct information to the pupil at a receptive period of life. The facts about prevention of mosquito-borne diseases should be interwoven throughout the school curriculum.

Scouts Aid Clean-up Drive

Teaching units on mosquito-borne diseases were prepared and used in many schools. In Charleston, South Carolina, and Savannah, Georgia, special student surveys were conducted. Each student inspected his own home and eliminated mosquito breeding places. Results were reported on forms showing name, address, and number of containers eliminated. Special problems were also reported.



Mosquito Control Education in an Elementary School

School children were further activated by an *Aedes aegypti* clean-up program. Two teachers, devoting full time during the summer vacation period, organized school children into "Skeeter Sentinels." These patrols met once a week at their schools and went out as clean-up gangs to eliminate mosquito breeding places in their neighborhood.

School children played an important part in the control of the dengue epidemic in Honolulu. The principals, teachers, and school nurses were instructed in dengue mosquito control by movies and demonstrations at a mass meeting. They, in turn, conducted the special student survey during which school children made over 25,000 separate inspections and eliminated over 30,000 water holding containers, of which 17% contained mosquito wrigglers.

Two members of the MCWA staff devoted full time to malaria education during the winter season. Extensive use was made of motion pictures and film strips, and practically every school child in Mississippi County and Jefferson County, Arkansas was reached. A number of malaria units have been established in schools during the past year as a result of previous community education programs.

PROFESSIONAL GROUPS

The need for education of professional groups on methods of preventing mosquito-borne diseases becomes increasingly apparent when we observe their role in creating and tolerating these diseases in their professional activities.

Malaria control is essentially an engineering job, yet most engineers are taught little about how to build malaria out of construction jobs. The result is an anomalous situation wherein one group of engineers, through ignorance or indifference, is busily engaged in creating malaria hazards while another group of engineers is engaged in eliminating the hazards so created. The answer to this glaring defect is the incorporation of malaria control principles and other phases of sanitary engineering into the general curriculum of engineering schools. The MCWA program has assisted in this field by furnishing motion pictures and informational materials to engineering professional groups and engineering schools. Members of the operational staff of the headquarters office also assisted with professional education by a series of lectures at Vanderbilt University and at the DeLamar Institute at Columbia University. Lectures

have been given by various members of the MCWA staff to other engineering groups.

Lack of interest, and in some cases a lack of technical information on the preventive aspects of mosquito-borne diseases, is noted in the medical profession. In the most malarious areas of the United States physicians are encountered who take little interest in careful malaria diagnosis and malaria reporting. There is also a lack of interest and support for mosquito abatement as a disease preventive measure. To increase the interest in and knowledge of mosquito-borne diseases among the medical profession it will be necessary to incorporate more facts about these diseases in the medical school curriculum and to assist in disseminating the facts more widely among medical practitioners. Various members of the medical and entomological staff gave approximately 50 lectures to medical students, medical societies, and other medical group meetings.

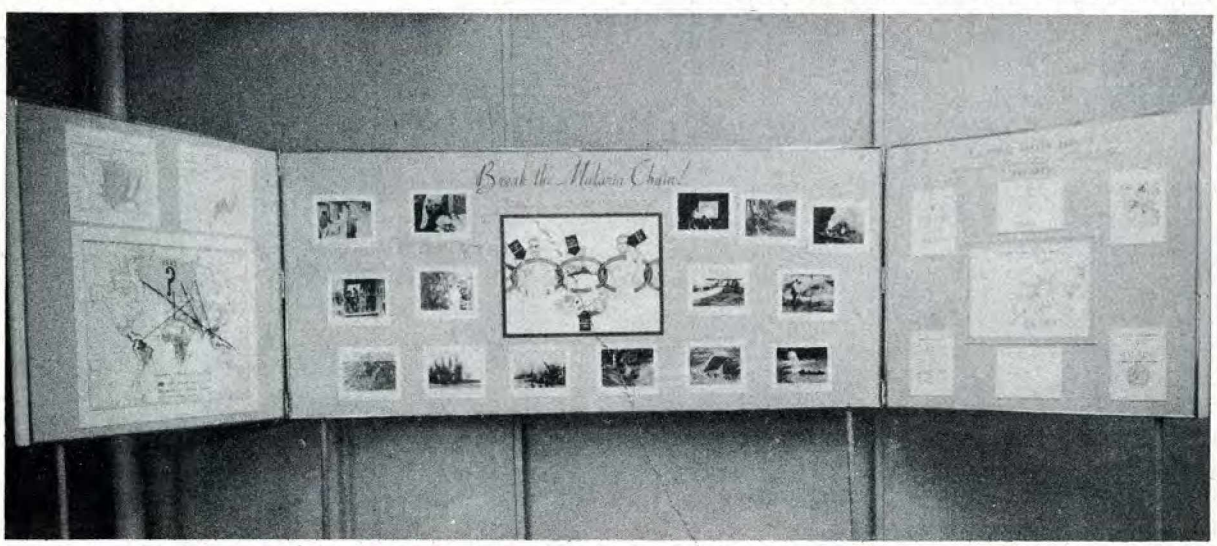
To assist further in the training of professional groups, a Kodachrome film is now being prepared on the diagnosis, treatment, and prevention of malaria for the medical profession. Another training film is being prepared on the microscopical diagnosis of malaria for technicians and physicians. A display on malaria prevention was prepared for the convention of Military Surgeons held in Philadelphia, Pennsylvania.

ADULT EDUCATION

The greatest challenge to education as a positive approach to prevention of mosquito-borne diseases is in informing and activating the general adult public. Formal adult education is not extensive enough to serve our purpose so other approaches must be used. To carry on the adult educational program several methods have been employed.

The *aegypti* educational work has been conducted primarily as a part of the operational program. Most of the educational work has been planned at the area level. Area supervisors delivered 1673 illustrated lectures to various adult groups. The *Aedes aegypti* inspector has made a special effort to inform and to activate the householder during his routine inspections.

For the malaria educational activities a summer community program was conducted as a line of secondary defense beyond the one-mile MCWA operation zones. Under the Chief of Field Activities in Health Education, 91 persons, most of them local teachers, were appointed to serve as malaria educators in 91 counties of thirteen States. These teachers were given preparation for the community educational program prior to their summers work. Each educator made a preliminary survey of the county in which he would work and attended a two week intensive training course in Memphis, Tennessee. During this period of



Display on Malaria Prevention Prepared for Meeting of Military Surgeons

Orientation Course for Field Workers in Malaria Education

orientation the educators were instructed in malaria and in methods of community health education. After the two week training period these educators returned to their respective health departments and, in most instances, worked under the direction of the county health officer. Their purpose was to inform and to activate individuals and communities on malaria and its prevention.

The malaria educators worked both with groups and individuals. They worked primarily with existing group organizations. It was generally found that the most effective work could be done by cooperating with the Office of Civilian Defense, home demonstration agent, county farm agent, civic groups, churches, Boy Scouts, and school groups. In certain instances, a great number of people were reached at incidental gatherings in farm yards, at picnics, church suppers, and health department clinics. About 3000 meetings were held or attended by malaria educators. More than 19,000 personal interviews were reported. In many instances anopheline

INFORMATION		ACTIVATION	
MEETINGS ATTENDANCE - 142,068	2,699	HOUSES SCREENED AND SCREENS REPAIRED	10,470
PERSONAL CONTACTS	19,609	DITCHES CLEANED OR DUG (MILES)	14
NEWS ARTICLES (COLUMN INCHES)	4,951	BREEDING PLACES CONTROLLED	458
RADIO PROGRAMS BROADCAST TIME - 30 HOURS	384	COMMUNITY CONTROL PROJECTS STARTED	72

Results of Community Malaria Education for the Summer of 1943

mosquito breeding places were inspected and householders instructed specifically on what to do to protect themselves and their families from malaria.

By malaria education the incidence of malaria and the dangers of transmission can be reduced in the broad area beyond the one-mile MCWA operation zone. The cost in manpower, materials and equipment for extension of MCWA control activities into this area would be prohibitive.

INFORMATIONAL CHANNELS

Since newspapers reach a large proportion of the public, MCWA has used this medium extensively, 5000 column inches appearing on the subject of dengue-yellow fever control. In some instances local firms donated space for messages on both yellow fever and malaria.

Through the assistance of the Division of Public Health Methods, nine cartoons have been prepared as newspaper mats for use in *Aedes aegypti* control work. Ideas for these cartoons were suggested by area supervisors and were stimulated by the needs which field men noticed from day to day. Cartoons such as these attract more attention than long articles.

On the radio, short quiz programs and spot announcements have been employed both in dengue-yellow fever and malaria control work. More than 50 hours of broadcast time have been consumed by these programs.

The 16mm motion picture and 35mm film strip are visual aids which are effective means of reaching small groups such as service clubs, schools, and church groups. They serve best when used in conjunction with brief discussions. MCWA has prepared a short Kodachrome motion picture for use on the *Aedes aegypti* control program. This film tells the story of individual and community action against the dengue-yellow fever mosquito. A series of colored film strips on malaria are also being prepared. Extensive use has been made of the malaria film strip prepared by the Division of Public Health Methods and the motion picture "The Winged Scourge" prepared for the Office of the Coordinator of Inter-American Affairs. The Division of Public Health Methods assisted in preparing posters, window displays, billboards, premise bulletins, and handbills for use in educational campaigns against *Aedes aegypti*. Many *aegypti* and malaria educators designed and prepared their own window displays and stimulated individuals in the communities where they were working to prepare posters for local use.

Movies are Effective in Malaria Education

The most effective, though time-consuming, educational procedure is to inform people through personal interviews, by demonstrating specifically the problem and its solution. *Aedes aegypti* inspectors personally interviewed 968,337 persons during the year and indirectly contacted other members of households, reaching a grand total of over two million people. Courteous, informative interviews were conducted by the inspectors in order to help the householder clean up his premises. An attempt was made to impress the householder with the necessity of being his own inspector. He was shown exactly what to do to prevent mosquito breeding; and where conditions were most serious, the premises were rechecked to make sure that the necessary corrections had been made. Seven hundred and twenty nine of these checkbacks in Savannah, Georgia revealed that the householders' work was 94% effective.

Although education is generally considered to be a long term approach, it is clear that it has an immediate effect in dengue-yellow fever control. Education

makes the entire *aegypti* campaign possible in the face of our acute manpower shortage. It would be impossible to do for the householder what he can be stimulated to do for himself through education. With our present funds *aegypti* projects can only be operated in 12 key cities. Educational methods are our only hope at present for covering the many other critical cities in the Southeastern United States. The *Aedes aegypti* Division has carried on an extensive educational campaign in these non-project cities.

FUTURE PROSPECTS

Never before have so many people been mindful of insect-borne diseases, nor have so many doctors, engineers, and entomologists been trained in malaria control. The war has raised serious problems in the control of malaria and other mosquito-borne diseases but these problems are being met, and the war is setting the stage for the greatest mosquito control effort in history. If the proper sort of educational work is done, individuals and communities will incorporate mosquito abatement in their post-war planning and will carry on with local funds the work which was inaugurated as a wartime emergency with federal funds.

Community-sponsored Mosquito Control

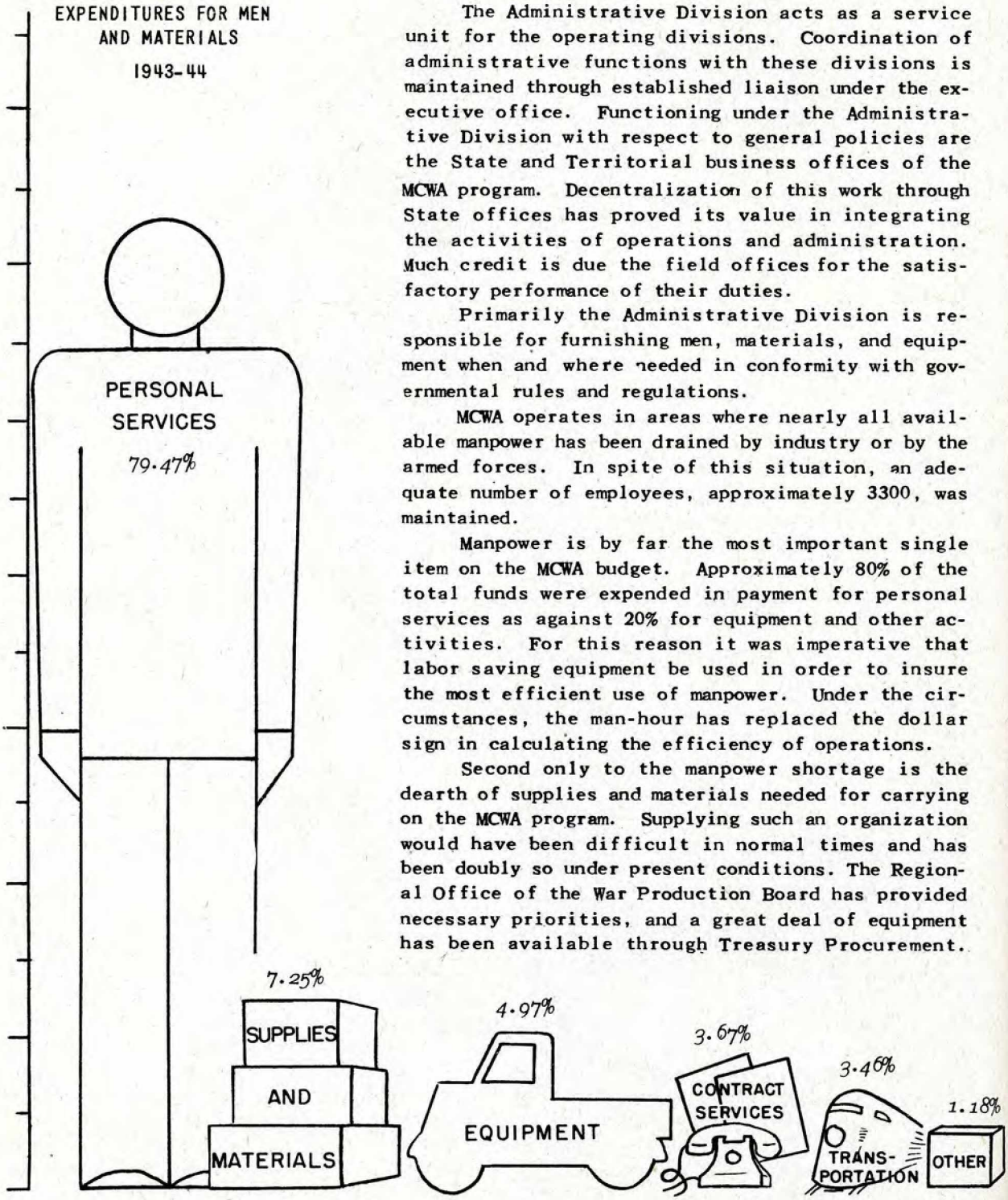
Billboard Publicity for *aegypti* Control

It seems apparent that malaria education has served us well. The remarkably low incidence of malaria in the United States today has been attributed to many influences, not the least of which is education. Malaria education has been cumulative--the long term approach of former years becoming the solution of today.

In a paper delivered at the Fourth Annual Conference of Malaria Field Workers at Chattanooga, Tennessee in November, 1922, Assistant Sanitary Engineer Leslie C. Frank said, "Malaria control education .....must be begun and never ended. It must become a permanent part of the school program. It must be ceaselessly pressed through the channels that reach adults.... it is the most important part of our problem. Malaria control education will be the ultimate secret of malaria eradication; and a given amount of money, if spent upon education, will yield very much more than if spent upon any other phase of malaria control."

His statement is as true today as it was a quarter of a century ago.

ADMINISTRATION



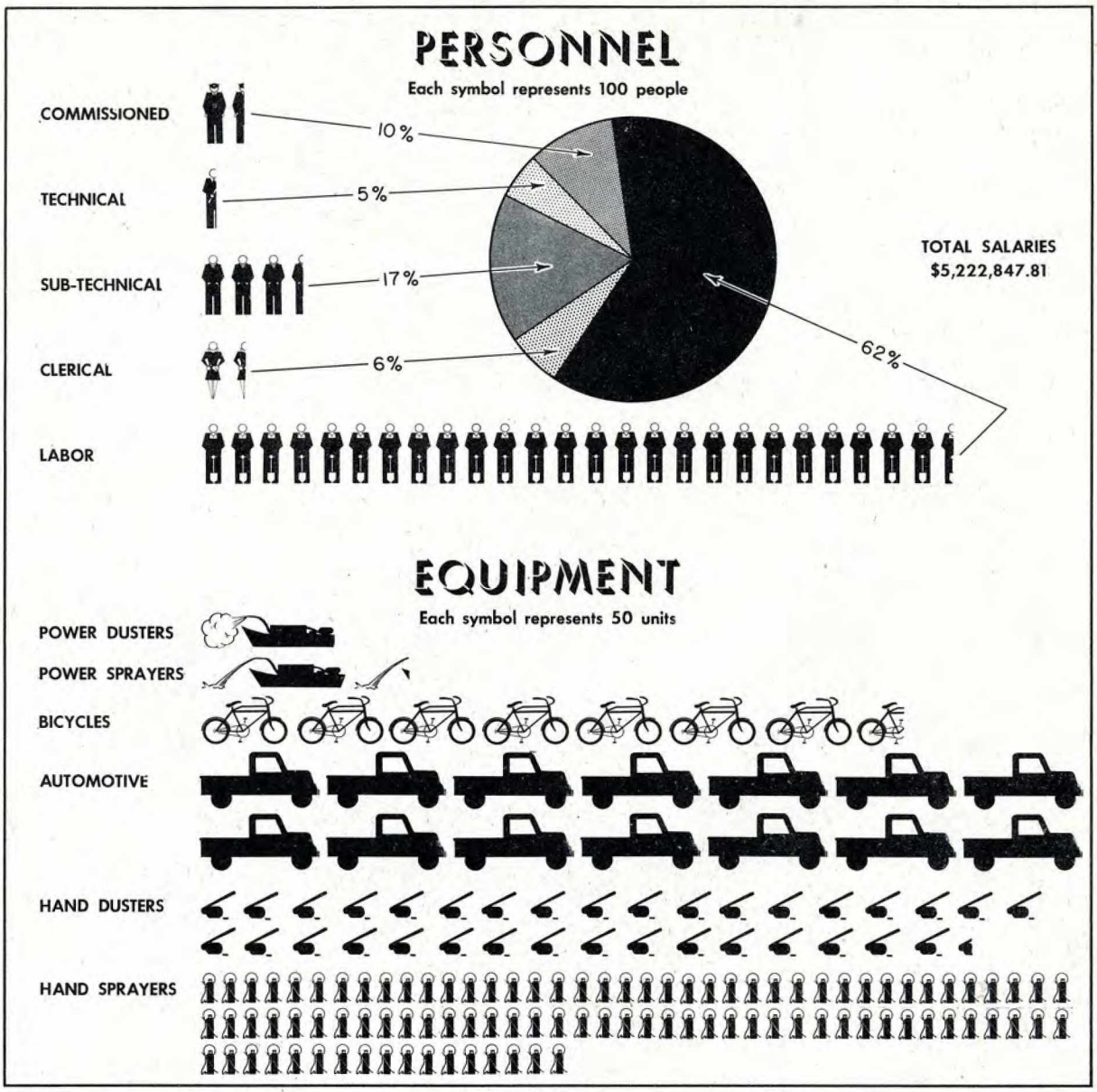
The Administrative Division acts as a service unit for the operating divisions. Coordination of administrative functions with these divisions is maintained through established liaison under the executive office. Functioning under the Administrative Division with respect to general policies are the State and Territorial business offices of the MCWA program. Decentralization of this work through State offices has proved its value in integrating the activities of operations and administration. Much credit is due the field offices for the satisfactory performance of their duties.

Primarily the Administrative Division is responsible for furnishing men, materials, and equipment when and where needed in conformity with governmental rules and regulations.

MCWA operates in areas where nearly all available manpower has been drained by industry or by the armed forces. In spite of this situation, an adequate number of employees, approximately 3300, was maintained.

Manpower is by far the most important single item on the MCWA budget. Approximately 80% of the total funds were expended in payment for personal services as against 20% for equipment and other activities. For this reason it was imperative that labor saving equipment be used in order to insure the most efficient use of manpower. Under the circumstances, the man-hour has replaced the dollar sign in calculating the efficiency of operations.

Second only to the manpower shortage is the dearth of supplies and materials needed for carrying on the MCWA program. Supplying such an organization would have been difficult in normal times and has been doubly so under present conditions. The Regional Office of the War Production Board has provided necessary priorities, and a great deal of equipment has been available through Treasury Procurement.

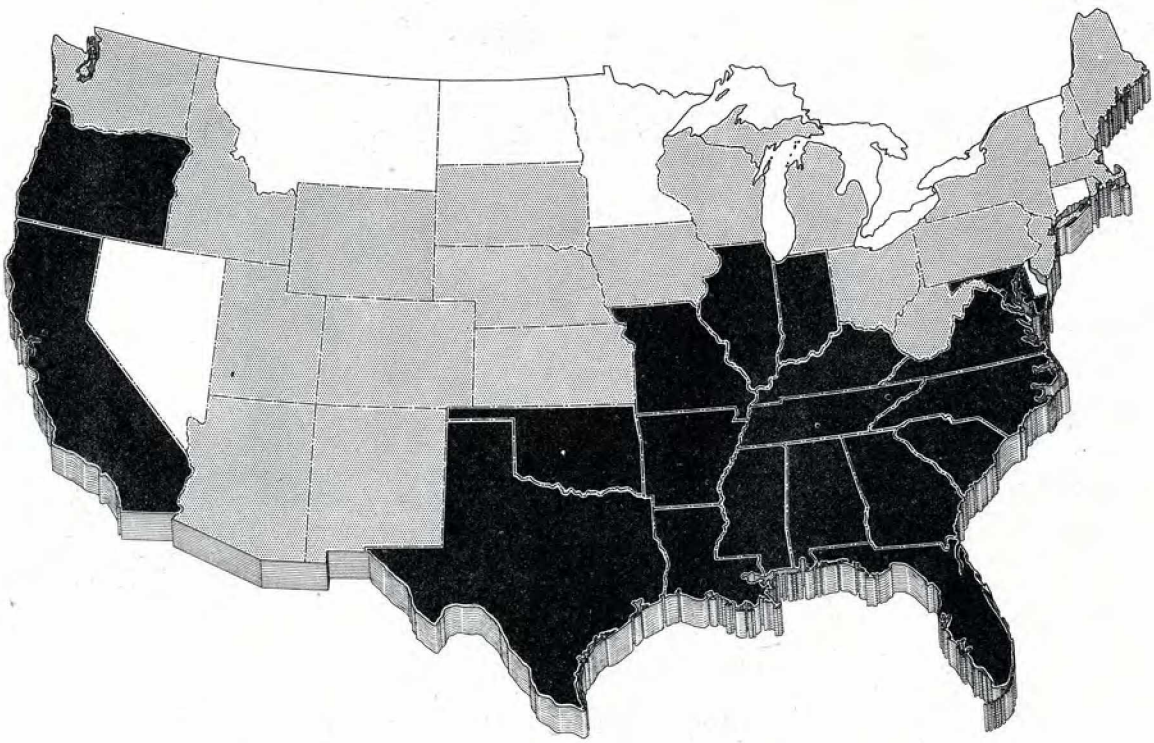


Some vitally needed pre-war equipment was obtained by transfer from other government agencies, particularly from WPA and NYA. Most of this type of property has now been allocated so it may become impossible to fill needs from this source in the future.

Automotive equipment has been particularly scarce. Since the Appropriation Act prohibits the purchase of new or used passenger carrying vehicles, more efficient utilization of the equipment already on hand was the only answer. The States showed a fine spirit of cooperation in this effort. In Virginia and in Puerto Rico, for example, repair shops were set up which made these projects practically independent of the overcrowded private shops and garages. Major repairs can now be handled through a central garage and repair shop in Atlanta.

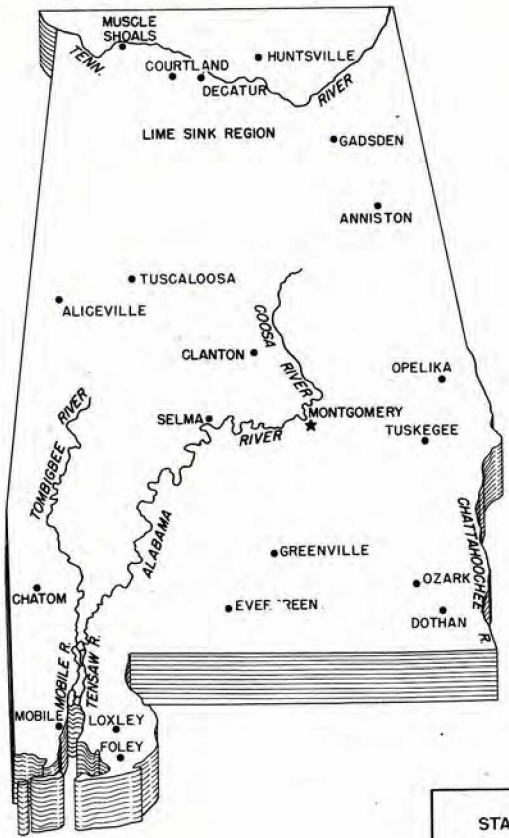
During the year arrangements were made permitting the auditing and payment of miscellaneous public vouchers in Atlanta. This arrangement naturally reduces the time of payment and has improved operating conditions of the entire MCWA program.

MALARIA CONTROL IN THE STATES



MCWA administrative offices have been established in 19 States, the District of Columbia, Puerto Rico, and the Territory of Hawaii. In 22 additional States programs were operated in the vicinity of prisoner-of-war camps and Army and Navy general hospitals. In these areas, the problem is handled by mobile units.

ALABAMA



During the past six years the trend of malaria in Alabama, as in other southeastern States, has been decidedly favorable. However, it would be presumptuous to assume an attitude of complacency because malaria is still taking its toll. In the southern and south central portions of the State, relatively flat topography and the broad flood plains of the major streams provide suitable breeding places for *Anopheles quadrimaculatus*. The northern portion is characterized by "lime sinks" resulting from the disintegration of limestone strata closely underlying the surface of the ground. In the north central and northeastern sections the topography is hilly or mountainous. The rapid rate of run-off in these areas is not conducive to the formation of mosquito breeding areas. Therefore, malaria has never been a serious problem in this region.

STATE HEALTH OFFICER
BURTON F. AUSTIN M.D.

BUREAU OF SANITATION

STATE OFFICE M.C.W.A.

21 WAR AREAS
111 WAR ESTABLISHMENTS PROTECTED

Nineteen of 36 military establishments and 49 war essential industries are located in or near areas where malaria is of sufficient importance to warrant control measures. Practically all of these essential industries are located in the Mobile Area.

With the exception of a narrow strip bordering the Gulf of Mexico, topographic features of the State are favorable for drainage. Consequently, the policy of eliminating mosquito breeding areas, wherever feasible from an economic and engineering standpoint, has been adopted. A program of major drainage around war areas was instituted early in 1941 with the assistance of the WPA and continued under the MCWA program. As a result, the significant and permanent anopheline breeding areas effecting military and essential war establishments in most instances have been completely eliminated. This accomplishment has not only greatly improved mosquito control but also has made possible a considerable reduction in labor forces.

During the year 18 areas, embracing 36 zones, were under active control, varying in scope from major drainage projects to larvicidal operations and inspectional service. Routine larvicidal operations were necessary in the Mobile Area where insufficient fall renders drainage impossible. Larvicidal treatment of temporary bodies of water, construction of minor drainage systems and maintenance of major drainage projects were in force in ten areas and constituted the major function of the program. Routine entomological inspections were the only measures necessary in seven areas.

A unique filling material was used in

Loading Sawdust into Truck

Spreading Sawdust

Sawdust Fill Completed

the Mobile Area. Several small bodies of water having a total area of approximately three acres were filled with sawdust. The availability of material, its ease of handling, and a flat topography with a rather slow rate of run-off are factors contributing to the success of this operation. When using this type of material for filling, approximately 25% should be allowed for settlement.

Prisoner-of-war camps were the only military establishments activated in the State during the year. Two of these, which are central camps, were located within the reservations of military installations already under control. Six prisoner-of-war branch camps were also located within the State. Fortunately, five of these are in areas considered relatively free of *Anopheles quadrimaculatus* and consequently have been operated as inspectional services. The sixth, located at Chatom, is almost surrounded by areas potentially capable of producing the malaria mosquito. Through arrangement with the Army, prisoners of war are being utilized on larvicidal treatment of these areas under the general supervision and direction of personnel attached to the MCWA program.

The agreement between military authorities and other agencies interested in the location of temporary prisoner-of-war camps, whereby the State Health Departments will be requested to inspect and report on the sanitary conditions existing at proposed sites, should prevent the selection of areas in which malaria is considered a serious problem. Inspections have been made and eports prepared for four proposed sites of prisoner-of-war camps at the request of the War Manpower Commission.

In constructing the two major drainage projects, methods commonly practiced in ditching with dynamite were successfully employed. It is interesting to note that one of the projects resulted in the elimination of approximately 400 acres of water surface by the construction of 37,000 linear feet of ditch involving excavation of 36,250 cubic yards of material. The relatively excessive length of ditch was necessary in order to secure a suitable out-

Treating Fire Barrel with Phenothiazine

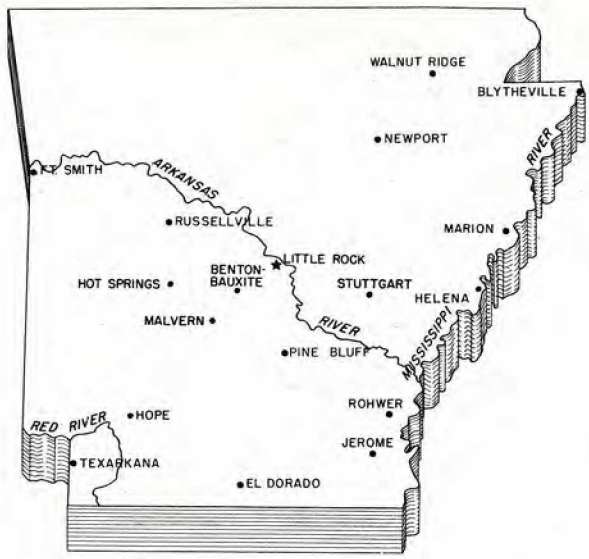
let. In connection with this project, a concrete pipe having a diameter of 54 inches was installed under a main highway. Thirty-two feet of this pipe were jacked through the highway fill 14 feet below the road surface, using hydraulic jacks. Considerable difficulty was experienced during this operation because of the sloughing of material and the necessity of continuously pumping large quantities of water from the working pit. Although this undertaking was successful, it is the opinion of those in charge of the work that in the future all other methods should be considered before hydraulic jacking is chosen for such projects, particularly if the ground water table is near the surface and if the soil is of a plastic nature.

The success of the year's work can best be measured by the densities of malaria vectors in the index zones of control, and by the incidence of malaria among persons whom control efforts are designed to protect. Of 18 areas now under some form of control, two, Aliceville and Mobile, showed density indexes of 10 or more *Anopheles quadrimaculatus* in "A" zones at some time during the year. Comparing the periods July through September 1943, and May through June 1944, inclusive, the average density per "A" station for Aliceville was 4.77 while that for Mobile was 1.78. The situation in Aliceville is believed to have been considerably improved by the construction of a major drainage project during the winter of 1943-1944. The intensified larvicidal program should result in a reduced anopheline population in the Mobile Area. The number of cases of malaria occurring within military reservations is not available. However, the matter has been discussed with responsible officers, and it appears that local transmission has been almost negligible, the majority of cases being of overseas origin.

In addition to the malaria program, an *Aedes aegypti* control unit was established in Mobile during March 1944. This unit is composed of a supervisor, an assistant supervisor, and eight inspectors. The program is progressing favorably and has been well received by citizens of Mobile. The local newspaper and civic organizations have cooperated to the fullest extent with the control unit and the Board of Health.

Boy Scout Clean-up Crew in Mobile

ARKANSAS



Approximately 80% of the war areas in Arkansas are located in the malarious section of the State. This area is in the flood plains of the Mississippi, Arkansas and Red Rivers.

During the year 17 war areas, consisting of 62 zones, were protected by the MCWA program. The principal work in each area was larviciding and minor drainage accomplished by hand labor. It was impossible to effect satisfactory control with manually operated equipment in certain areas, so it was necessary to dust by airplane and with power dusters and to oil with power sprayers.

STATE HEALTH OFFICER
T. T. ROSS, M.D.

BUREAU OF SANITARY ENGINEERING

STATE OFFICE M.C.W.A.

18 WAR AREAS
88 WAR ESTABLISHMENTS PROTECTED

A summary of the cost of the MCWA program in Arkansas was prepared on the basis of square miles of area actually controlled. In flat, poorly drained areas where extensive larviciding, clearing, or major drainage operations were necessary, the cost was $1531.00 per square mile. By contrast, in hilly areas, where drainage was much better and where control was obtained primarily by larvicidal measures, the cost was only $633.00 per square mile.

In the Stuttgart Area an advanced Pilot Training School is located in the midst of the largest rice growing area in the State. Within one mile of the cantonment area of the School there are approximately 28 acres of rice. It was not considered justifiable to treat this small area with paris green by means of an airplane, so a spray program was set up to kill all adult "*quads*" before they could become infective.

In this same area experiments were carried on in cooperation with the Rice Branch Experiment Station of the University of Arkansas to determine the effect of paris green dusting on rice plants. Tests showed no apparent effect on the yield of rice or rice straw. Tests were carried on in cooperation with the Memphis Laboratory of the National Institute of Health to determine the larvicidal effect of DDT when added to irrigation water. Results are not yet available on these tests.

The Walnut Ridge and Newport Army Air Fields are located near extensive rice fields. The rice fields remain flooded practically continuously from the end of May to the middle of September, providing a source for extremely heavy *Anopheles quadrimaculatus* breeding. Airplane dusting with paris green gave satisfactory control at the Newport Air Field, but there was not sufficient reduction in anopheline breeding in the rice field which lies within the city limits of Walnut Ridge. Airplane dusting with DDT was tried in cooperation with the United States Department of Agriculture but the tests were inconclusive.

In seven areas there were located large bodies of water which were too small to justify the use of an air-

plane and too large to be controlled adequately by hand operated equipment. The most practical method of controlling these areas was with a power dust unit or power spray unit mounted on a boat. Seven boats 5 feet wide, 14 feet long, and 18 inches deep were built for this purpose. Each boat was driven by an outboard motor. One man operated the motor and one man operated the power unit. The water-oil unit consisted of a centrifugal pump which sucked lake water and oil into the pump, mixing the two together. The pressure which was built up by this pump would throw the water 50 to 60 feet. The weight of the water was sufficient to carry the oil down through shoreline vegetation such as cattails, water grasses, water lilies, and other types of aquatic growth, enabling the oil to reach the surface of the water. The spray reached back into the willows, which had grown up along the shoreline for 25 to 30 feet. The amount of oil used in the pump unit averaged approximately ten gallons per acre of water surface treated. This was found to be one of the most economical methods of controlling large bodies of water.

Airplane Dusting Rice Field

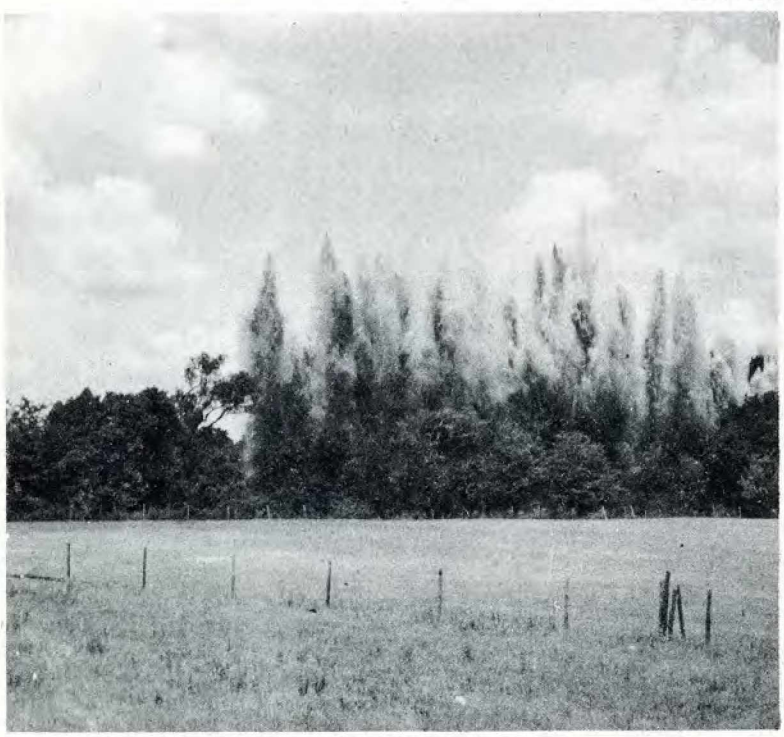
Rice Plants

Checking for Larvae in Rice Irrigation Water

Large swamps and bodies of water which were impossible to control adequately with larvicides were drained. A dragline was used instead of dynamite when a large quantity of sand was found in the soil, or when the soil was excessively dry. At Helena, 14,300 linear feet of ditch varying from 3 feet to 10 feet in depth were constructed by dragline. At Jerome it was necessary to clean out 17,000 linear feet of existing drainage ditch in order to accomplish drainage of a swamp of approximately 250 acres. An average of three cubic yards of dirt per running foot was moved at a cost of 18¢ per cubic yard. A State total of 31,800 linear feet, or 6 miles of ditch, was completed.

Dynamite was used throughout the State in draining swamps and sloughs in which the soil was so wet it was impossible to move a dragline into the area. In such places dynamiting is considered to be the most effective and quickest method of securing adequate drainage. Certain dynamiting jobs were completed before it would have been possible to move a dragline from one location and walk it into the area. Ditches

Constructing Ditch with a Dragline



Dynamite Ditch Blast

varying in size from 18 inches in depth with a 5-foot top to ditches 5 feet in depth with a 15-foot top were constructed in the State by this method. Where dynamite was found to be more economical it was used in preference to any other method.

A blood survey was conducted in 34 counties during the summer and fall of 1943. A total of 32,341 slides were made. Most of these slides were obtained in schools, but 1,243 were secured in a house-to-house survey. By the end of the fiscal year, 17,637 of the slides had been examined. Only .09% of the total number examined were positive for malaria.

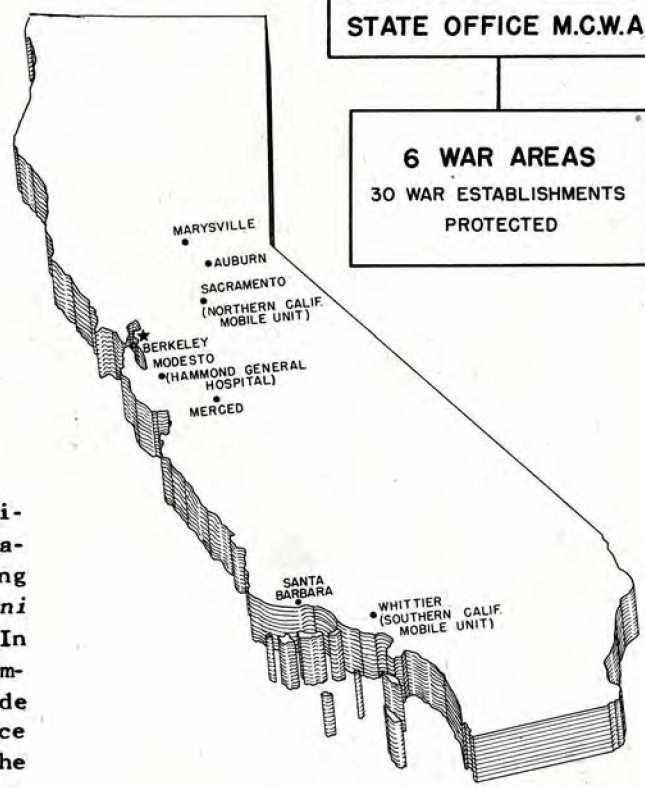
CALIFORNIA

DIRECTOR OF PUBLIC HEALTH
WILTON L. HALVERSON M.D.

BUREAU OF SANITARY ENGINEERING

STATE OFFICE M.C.W.A.

6 WAR AREAS
30 WAR ESTABLISHMENTS PROTECTED



History records the presence of malaria in California at the time of the Gold Rush in 1848 and 49. From that time until approximately 1900 records and reports were very meager, but those available indicate that malaria of epidemic proportions was scattered in the low foothills and across the floor of the area known as the Great Central Valley. Since early days, malaria has been closely associated with agriculture through the use of water for irrigation purposes. In Southern California where water is comparatively limited, only a few cases of malaria have been recorded.

The Central Valley is 30 to 50 miles inland from the coast, which it parallels, and is approximately 500 miles long by 40 to 70 miles wide. Numerous streams and rivers originating in the mountains flow onto and traverse the floor of the Valley, providing extensive breeding areas for *A. freeborni* which is the western malaria vector. In addition, man-made canals, ditches and impoundments used for irrigation provide suitable breeding places. Irrigated rice fields in the north central portion of the Valley where the soil is permeable, are often responsible for heavy breeding of *A. freeborni*.

Anti-anopheline measures for malaria control have been practiced in California since 1910, although pest mosquito campaigns were inaugurated as early as 1907. The malaria rate began to decline about 1920 and has reached such a low point in the last few years that only a few cases have been reported yearly. Nevertheless, in the Central Valley *A. freeborni* is very abundant, sometimes exceeding 5000 overwintering individuals per resting place.

California is experiencing an enormous amount of military activity. There are many Army, Naval and Marine camps handling not only military personnel leaving this country for war theatres, but also many that are returning from highly malarious battle zones for temporary assignment and regrouping into new combat units. Many of these establishments are located within the region where, in former years, malaria was endemic. In some of these, men are being hospitalized and treated for malaria.

Two mobile units were allotted to the California program in March 1943. One unit was established in northern and the other in southern California to carry on approximately semi-monthly inspection and anopheline control near general hospitals and

prisoner-of-war camps. These units are also considered as emergency units and are available at a moment's notice should a malaria outbreak occur anywhere in the State.

During the fiscal year 1943-44, MCWA established anopheline control projects on a 12-months basis around two general hospitals, two cities, and two Army air bases located within the Central Valley, using standard diesel oil as a larvicide. During the summer and fall of 1943 all larviciding oil was applied with hand sprayers. To facilitate the application of oil and because of an acute manpower shortage, two power sprayers were put into service at the beginning of the spring breeding season in March of 1944. In each control area hand ditching, brushing, and clearing supplemented the larviciding work.

Another and equally important phase of the MCWA program was the inspection work around many military establishments throughout the State. These inspections, made from time to time, determine the presence and density of the malaria vector.

Anopheline species common to the Pacific coast have not previously been reported breeding in anything but fresh water. However, *Anopheles freeborni* larvae were collected in water reached by high tides along the beach at Santa Barbara in August 1943, and again in the Sorrento Wash Area near Camp Callan about 15 miles north of San Diego in the spring of 1944. This wash for a distance of 1½ to 2 miles inland from the ocean is heavily overgrown with *Salicornia* and an analysis of the water showed a saline concentration equivalent to 17% sea water.

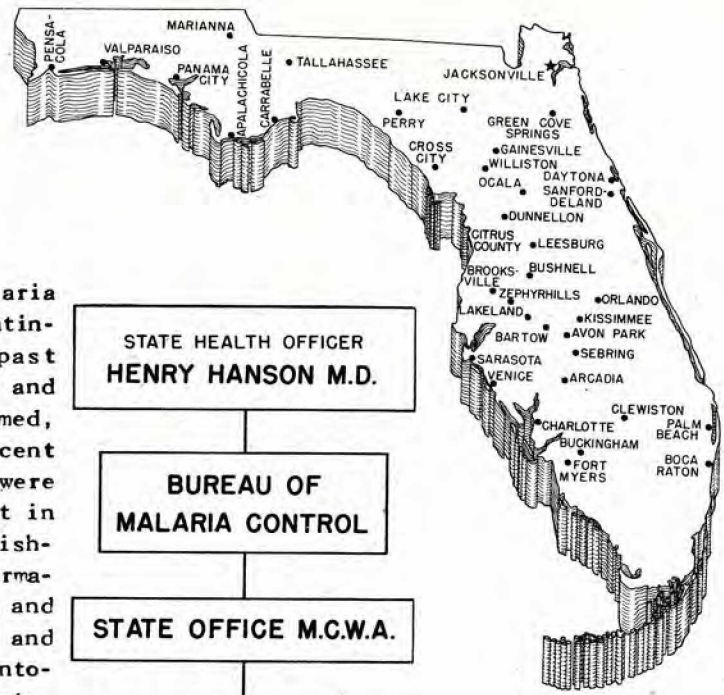
Along the cool coastal belt of the State there is no history or record of malaria transmission, even though *A. freeborni* is present at scattered spots. It may be that the mean average temperature of this area is not sufficiently high for favorable development and transmission of the plasmodia in the mosquito. Due to the lack of evidence of transmission, the potential malaria problem in this section does not seem to be very great. However, because of the heavy concentration of military personnel where a known capable vector is present, inspection and some control is being carried on primarily by mobile units.

Very close inspectional service is being maintained at Hamilton Army Air Field because it is one of the main ports of entry for planes from the Pacific.

Breeding Place of *Anopheles freeborni*

Dragline Ditching Eliminates Breeding Area

FLORIDA



STATE HEALTH OFFICER
HENRY HANSON M.D.

BUREAU OF MALARIA CONTROL

STATE OFFICE M.C.W.A.

37 WAR AREAS
115 WAR ESTABLISHMENTS PROTECTED

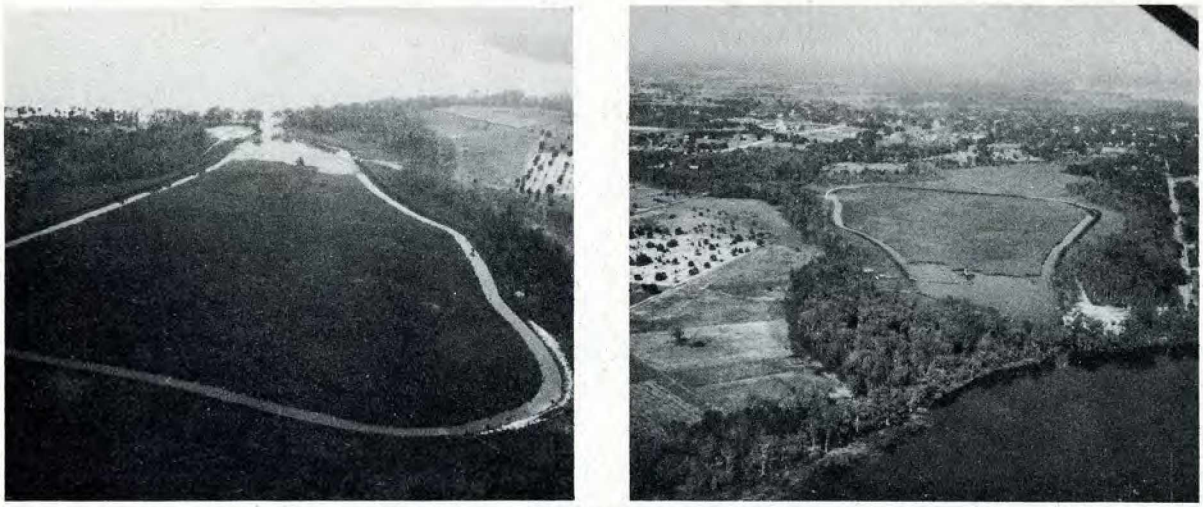
During the past fiscal year malaria transmission throughout Florida continued its steady decline of the past eight years. Extensive spleen and blood smear surveys were performed, particularly in populations adjacent to war establishments, and rates were found to be relatively low except in Citrus County where no war establishment has been located. Since information provided by present blood and spleen surveys is limited, more and more reliance has been placed on entomological inspections in the orientation of control work.

Special entomological studies were made in 31 areas not under control, to determine whether regular working crews would be required to keep mosquito breeding within safe limits. As a result of this work seven new projects were established. The location of eight prisoner-of-war camps in Florida prior to July 1 required prompt field studies to evaluate the local malaria hazard. In only one case was it found that control could not be achieved with the resources available. The installation of various convalescent hospitals for overseas veterans had led to special entomological surveys which necessitated the inauguration of regular area operations at Daytona Beach.

Twenty areas were selected for minor drainage and larvicidal operations. This represented control around approximately one hundred different war establishments. In addition, major drainage involving dynamite blasting of large canals was done in nine of these areas. This work has given excellent results and has proven to be an economical solution to many serious drainage problems. Dragline ditching was utilized in Tallahassee, Leesburg Service Center, and Sarasota - in some cases with the assistance of local civil or military authorities. Oiling and dusting operations for the present season have been reduced over last year as a result of engineering work during the winter. In fact, dusting is being used in only three areas at the present time.

A problem which still remains unsolved is the destruction of water hyacinths by some economical method. Many herbicides and aquatic weed killers have been assembled for experimentation. The standard treatment with sodium arsenite cannot be generally employed because of the danger of poisoning livestock.

Leesburg is situated on a neck of land between two broad lakes, and several large sawgrass marshes extend inwards toward the city. These areas could be controlled by airplane dusting, but a locally-made hydraulic dredge has been supplied by the city and is steadily reducing the sawgrass marsh area which is responsible for continued anopheline production. MCWA cooperates with the city authorities by furnishing an operator and an assistant operator for the dredge. The dredge cuts a



Control of *Anopheles quadrimaculatus* by Dredging at Leesburg, Florida

channel around the marsh, throwing the spoil into a dike-line. The sod, muck, and sand are then pumped from the center behind the dike, and the marsh becomes a lake with clean margins. In this way the breeding areas are permanently corrected.

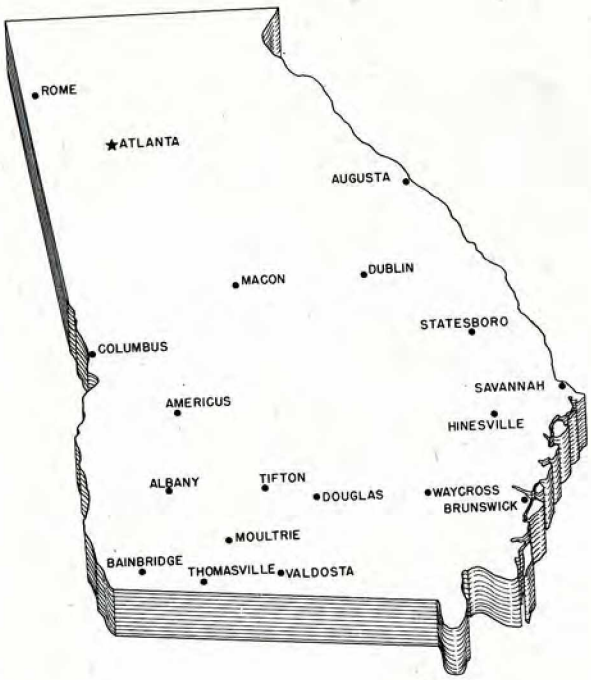
A gratifying result of the statewide emergency malaria control work performed by MCWA has been the numerous cities and towns that have formally requested assistance in converting the work to a permanent basis, using local funds. Among these are Tallahassee, Marianna, Gainesville, and Leesburg. Detailed engineering reports for these communities will be prepared with recommendations for future work. Under the supervision of the Bureau of Malaria Control in the Florida State Board of Health, these towns can assure themselves of freedom from malaria-carrying mosquitoes after the termination of the present emergency.

In addition to the malaria control program, *Aedes aegypti* control projects were in operation in three cities. These are Key West, Miami, and Jacksonville. Physical survey work for Jacksonville was completed around July 1 and plans were under way to create a surveillance unit in Tampa also. Educational campaigns were conducted in Miami and Jacksonville, and local governmental and civilian organizations were encouraged to assist in the campaigns. Public response has been excellent, but manpower shortages have made it most difficult to secure satisfactory inspectors. Public services related to the program - such as trash removal - have fallen behind the needs of Florida communities.

Throughout the year the MCWA program in Florida has had the assistance of experienced malariologists and engineers contributed by the State Board of Health and the Rockefeller Foundation as a supplement to the technical supervision of the Atlanta office. The various organizations have cooperated effectively from the start, special skills and experience being utilized to the utmost in assuring that the malaria hazard to military and vital industrial installations is reduced to a minimum.

Killing Adult Mosquitoes in a Cistern

GEORGIA



In Georgia, during 1943, reported malaria morbidity and mortality were very low as compared to previous peak years. The mortality rate per 100,000 population was 1.1, as compared with 19.8 in 1936 and 23.3 in 1929. The morbidity rate per 100,000 population was 15.0, as compared with 390.7 in 1936 and 235.8 in 1929. MCWA activities contributed to the statewide reduction of malaria, but there was also a startling reduction in malaria in areas unprotected by larvicidal programs.

STATE HEALTH OFFICER
T F ABERCROMBIE M.D.

DIVISION OF PUBLIC HEALTH ENGINEERING

STATE OFFICE M.C.W.A.

19 WAR AREAS
114 WAR ESTABLISHMENTS PROTECTED

War establishments were located throughout the State, but with the exception of Battey General Hospital at Rome, control activities were confined to those located in the lower half of the State where malaria is of sanitary significance. Judging by adult anopheline indexes in protected areas, there were only one or two locations during a brief period of the year where there was any likelihood of malaria transmission.

The control problem was not limited to any particular type of watered area. Controlled malaria mosquito breeding areas included natural and artificial pools, lime sinks, ponds, abandoned rice fields, abandoned and active brick yard excavations, power development reservoirs, swamps, ditches (both paved and unpaved), canals, and other water holding areas.

Since the inception of the State program in March 1942, plans and operations have been directed toward securing control of the malaria vector, *A. quadrimaculatus*, at minimum cost, in accordance with the original USPHS directive. Accordingly, larvicidal control measures have been confined to those locations in which "*quad*" breeding was demonstrated by larval collections. Paris green was selected as the main larvicide to be employed due to its proved effectiveness and lower cost as compared to other present known and available larvicides. No major drainage project has been, or will be, undertaken unless it can be shown that its cost can be amortized by the consequent saving of larvicidal costs during a reasonable period. Minor drainage has been confined mainly to maintenance or reconstruction of existing waterways and clearing and cleaning of areas to be larvicided, all of which are performed by crews ranging in number from 2 to 20 men per area whose principal duties are application of larvicides.

From April to October, the breeding season in most areas, every station showing the presence of "*quad*" larvae was placed on a weekly schedule of larviciding.

Principal breeding in the Macon area is found in brick yard excavations and permanent ponds. During 1943 extensive breeding developed in the Fuse Plant Zone swamp. This breeding was brought under control by large scale hand dusting operations and cleaning of the main outfall, utilizing manual and dynamite methods. A complete topographic survey was made of swamps, and plans were made for reconstruction of the outfall by means of a 4" hydraulic dredge. One pond was controlled by weekly fluctuations.

Hydraulic Dredge in Operation at Macon, Georgia

At Augusta, interesting features of control were the filling of shallow areas by the diversion of inflow to two ponds. Waste brick plant materials were hauled by plant trucks and, under MCWA supervision, used as minimum depth fill to eliminate shallow areas difficult to control. Some breeding areas were controlled by connecting them to varying stage industrial and sewage canals which fluctuated the water level.

Although Hinesville is in a very malarious section of the State, control by hand dusting has been satisfactory. Principal breeding is in a ditch fed by artesian wells, one of which is controlled by flushing methods effected by automatic siphon.

The malaria problem in Savannah is characterized by extensive breeding areas, including abandoned rice fields, in the vicinity of fresh water tidal canals and tributaries. Control by hand dusting was considered satisfactory except in the Port Wentworth and Quartermaster Zones. Remedial measures, including county installation of major tide gates, has been planned for winter months.

In Albany extensive breeding areas in the power development reservoir were satisfactorily controlled by Georgia Power Company personnel. MCWA hand dusting operations secured satisfactory control in other breeding areas.

A majority of the ornamental pools in the city of Moultrie were found to breed "*quads*" but very satisfactory control was obtained in this area by hand dusting methods.

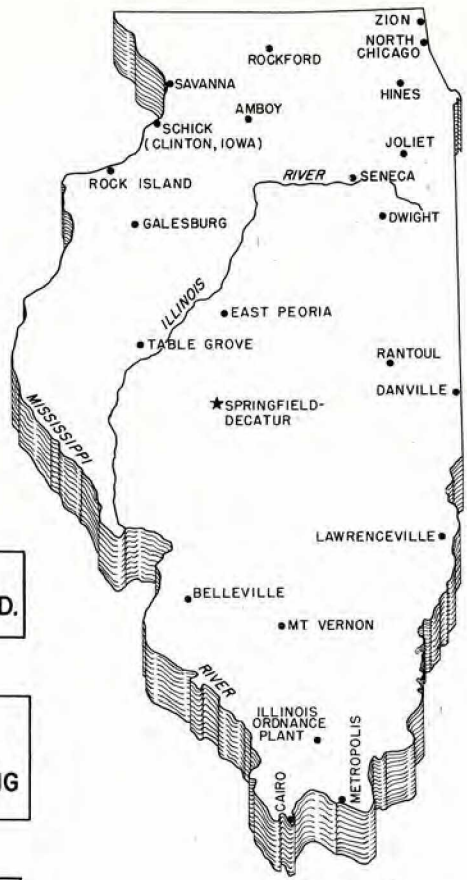
In Bainbridge plans were made for prosecution of dragline work to provide drainage outlet for several lime sinks.

In Americus limited breeding was controlled with hand dusting performed by County personnel using MCWA dusters and larvicide.

Hand dusting and minor drainage maintained satisfactory control in Statesboro. Ditch paving will be installed during winter months with the county and city furnishing all materials.

The success of the 1943 program might be confirmed by the fact that in no instance has any complaint or criticism of the work been received from responsible service officers of the military areas protected. Likewise, there has been no report of malaria infection caused by mosquito breeding in the control zones. Collection data obtained in the cantonment and extra cantonment areas are exchanged between the service officers and the respective area supervisors, providing full coordination.

ILLINOIS



DIRECTOR OF HEALTH
ROLAND R. CROSS, M.D.

DIVISION OF SANITARY ENGINEERING

STATE OFFICE M.C.W.A.

23 WAR AREAS
73 WAR ESTABLISHMENTS PROTECTED

Due to its geographical position, Illinois has often been referred to as a borderline State. The problem in malaria control has been mainly to determine just where the borderline is and to prevent the establishment of new foci of malaria. Until agricultural drainage was established on a large scale through the vast plain area of Illinois, malaria was widespread and endemic throughout the State. The endemic malarious area of the State now lies south of a line from St. Louis, Missouri to Terre Haute, Indiana. At times mild epidemic outbreaks may occur north of this line, usually along the Mississippi River or the Illinois River.

However, the distribution of *Anopheles quadrimaculatus* is quite general throughout the State and seems to be limited only by the absence of favorable breeding areas.

In the most southern portion of the State, however, the period of weather warm enough for anopheline breeding is commonly from 30 to 50 days longer than in the northernmost part, where the season of favorable conditions is comparatively short.

In war areas where malaria vectors are numerous, surveillance is maintained even though evidence of malaria transmission is lacking. Surveillance as conducted in these areas consists of the following activities: (1) entomological inspection of all areas in question to determine the actual "*quad*" breeding areas, the adult densities, and the potential danger to the area under protection; (2) close cooperation with military or other officials concerned, so that they are aware of conditions in the extra-cantonment area; (3) constant reporting and summarizing of all malaria cases in these areas through the Division of Communicable Diseases; and (4) tentative control plans for each of these areas which may be set up promptly, should they be needed.

Control measures were carried out in six zones in two areas in the southern part of the State during the past year. In the East St. Louis area the record-breaking Mississippi River flood of 1943 and the resultant backwater and seepage into the Parks Air College zone greatly increased the control problem there. Emergency measures were inadequate in repairing the Drainage District pumps, and the breeding season was almost terminated before the drainage system was able to draw the water to normal levels. Most of

the breeding areas caused by this condition were long, narrow sloughs which were satisfactorily controlled from the shoreline with a large, power-driven duster mounted on a small, 4-wheel-drive truck, using a larvicide of one part paris green to ten parts of lime.

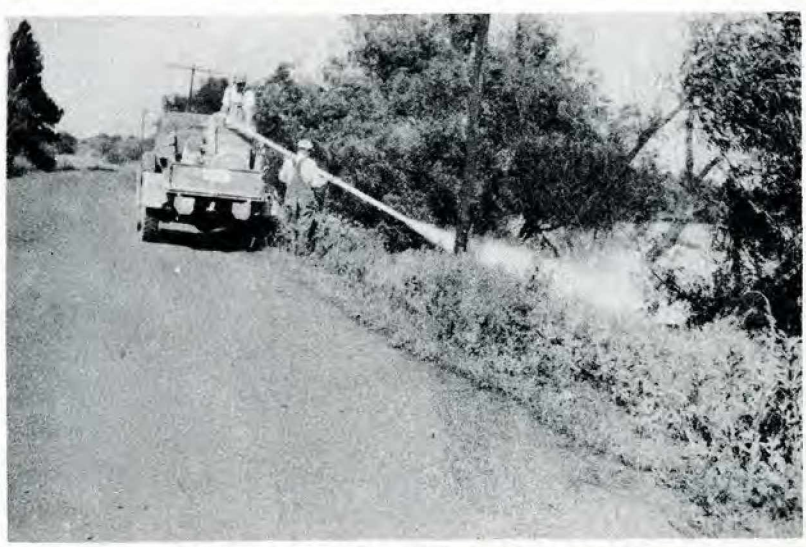
In the Granite City zone of the East St. Louis area counts as high as 5,000 *Anopheles quadrimaculatus* were recorded from points two miles from protected zones near a large lake breeding area, but at no time during the season did there appear to be any migration of this large population into the protected area. It is believed this may have been due to the large amount of smoke and fumes from factories located between the protected area and breeding sites.

The largest and most difficult control problem was Area #2, Illinois Ordnance Plant, where a large artificial lake with extensive breeding areas was producing great numbers of *Anopheles quadrimaculatus*. Power dusters mounted on boats, supplemented by a small power duster operating from a pick-up truck, affected fair control except in very thickly overgrown portions of the lake. In order to reach these areas and to insure adequate weekly treatment of them, control by airplane dusting is being undertaken during the 1944 season.

A local epidemic outbreak of malaria occurred in a small city near the Illinois Ordnance Plant area, where many workers from the war plant were housed. Initial surveys showed a high density of *Anopheles quadrimaculatus* present, ranging from 10 to 200 per collecting place, and approximately 75 potential *Anopheles quadrimaculatus* breeding areas, including unmaintained ditches and streams, mine ponds, stock ponds, artificial ponds, and natural swamp areas. Many of the swamps are caused by subsidence of the ground due to mining operations. A sudden drop in counts occurred soon after control measures were begun and were only partially attributable to our control operations. However, a large number of what appeared to be very suitable breeding ponds and streams had dried up about two weeks before MCWA operations began, and it seems possible that a natural drop in densities may have resulted.

Investigations in the northern areas along the Mississippi River indicated an abnormal drop in *Anopheles quadrimaculatus* populations from the 1942 season. A review of conditions existing throughout the two seasons indicated that frequent floods and water recessions on the Mississippi River and its tributaries during 1943 had produced effective natural control of breeding during 1943. This was most striking in the Savanna area where counts had been excessive during 1942, reaching 6,000 in one station, whereas in 1943 all stations remained less than 10 throughout the season.

In order to facilitate proper surveillance and to add to our control efficiency, complete maps of 22 areas were prepared during the winter months. These maps show accurately all potential breeding areas and their relation to the protected areas.



Dusting Shoreline of a Small Lake

INDIANA

STATE HEALTH COMMISSIONER
THURMAN B. RICE, M.D.

BUREAU OF SANITARY ENGINEERING

STATE OFFICE M.C.W.A.

10 WAR AREAS
41 WAR ESTABLISHMENTS PROTECTED

The State of Indiana is divided into two areas insofar as malaria control is concerned. In the area north of the 40th parallel of latitude, the degree of endemicity is believed to be low, although high "*quad*" breeding may be encountered for relatively short periods. The remainder of the State includes two well established areas of relatively high endemicity. Here the breeding season is of longer duration.

With the above division in mind the program for the fiscal year ending June 30, 1944 was planned. Inspections were made in the northern areas and epidemiological reports were studied. It was decided that the only area to be kept active, and this only on an inspectional basis, would be the Fort Wayne Area where "*quads*" have reached as high as 10 per station and where the Army has reported the presence of malaria patients. Certain areas in the southern portion of the State were considered to be of negligible importance either because of the absence of "*quads*" or of the absence of malaria, or both.

The Terre Haute Area, with its past history of malaria epidemics and the high "*quad*" counts recorded since the opening of MCWA activities, was considered highly important. The city of Terre Haute has had its own malaria mosquito control program since the 1938 epidemic. MCWA operations supplement this program by controlling a zone one mile wide around the city. Each spring the many lakes and depressions in this zone are flooded with sufficient water to remain for the entire summer. A major drainage project was instituted by which it was hoped to eliminate some of the extensive breeding areas. Unfortunately, early spring floods from the Wabash River prevented completion of this project. Larviciding with paris green and oil, and pumping some of the ponded water from behind the levees was attempted. However, it was found impossible to control this area without power equipment during 1943. If power spraying proves unsuccessful this year, dusting by airplane will be the only way to reduce "*quad*" counts.

Through an agreement with the City of Evansville, the city will furnish labor and automotive equipment for larviciding this highly industrial area. Evansville and Vanderburgh county have consistently reported a fairly high number of malaria cases, and "*quads*" are known to breed prolifically in the region. Evansville, located in the southwestern section of Indiana along the Ohio River and

Flood Conditions Near Terre Haute

Hand Spraying

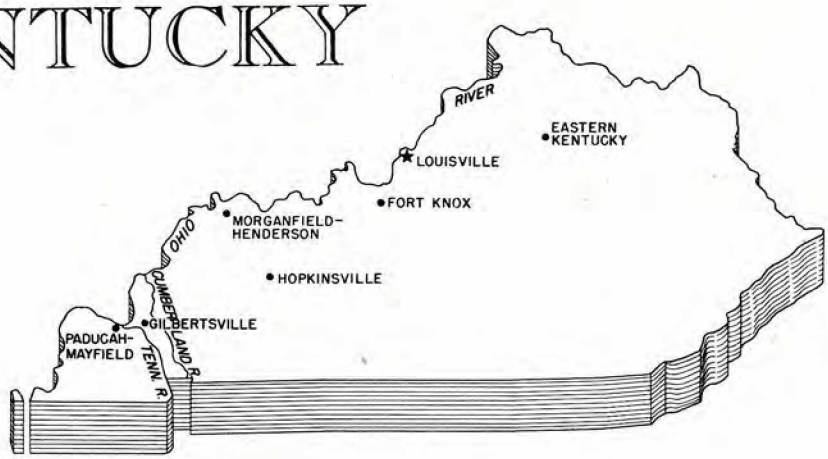
across from Kentucky, might well become a danger point if preventive measures were not taken.

The Army has considered the areas in the vicinity of Fort Benjamin Harrison, near Indianapolis, to be of sufficient importance to certify it for control measures. Plans have been made to begin operations if and when station counts become high enough to justify larviciding. Although no unusual problems have been encountered, areas along the Ohio, Wabash, and White river basins warrant surveillance, but it is hoped that control will not become necessary. Because of a relatively mild winter, early floods, and an early rise in temperature, the "*quad*" breeding season started five weeks earlier in 1944 than in 1943.

The MCWA program in the State of Indiana takes into consideration and affords protection to approximately 25 Army and Navy establishments and another 16, or more, war industries and recreational areas where soldiers, sailors, marines, and war workers congregate.

Dusting Near Terre Haute

KENTUCKY



COMMISSIONER OF HEALTH
P. E. BLACKERBY, M.D.

BUREAU OF SANITARY ENGINEERING

STATE OFFICE M.C.W.A.

6 WAR AREAS
51 WAR ESTABLISHMENTS PROTECTED

The State of Kentucky, although not a borderline State, is located toward the outer edge of the malarious belt, and only portions of the State extending westward from Louisville present malaria problems of serious proportions at the present time.

The eastern portion of the State ranges from rolling hills in the vicinity of Louisville to mountains along the Virginia boundary; while the western portion, although generally rolling, presents some flat areas in the valleys of the Tennessee, Cumberland, and Ohio rivers.

The average summer temperatures in the western end of the State are approximately two to three degrees higher than in the eastern end, and the rainfall in the western end is heavier than in the central and eastern portions.

Surveys have been conducted to determine the densities of *Anopheles quadrimaculatus* throughout the State. These indicate that the heaviest breeding occurs at the western tip of the State near Paducah, falling off to light breeding east of Lexington. There are large numbers of lime sinks and artificial ponds for watering livestock throughout the agricultural districts, and these furnish potential breeding places despite the rolling nature of the terrain.

Impoundment of the Dix River in the central part of the State has not increased "*quad*" breeding seriously, since the river has a clean-cut shoreline and the banks rise sharply, particularly in that part of the impoundment in which is included the Darnall General Hospital zone. A TVA impoundment on the Tennessee River has not yet been filled. This is created by the Gilbertsville Dam in the western end of the State, which will create a lake 184 miles long. TVA has laid careful plans and is building in many control measures throughout the reservoir.

The locations of most of the nine military establishments under surveillance or control have been well-selected from the viewpoint of malaria control, and for this reason no control has yet been required in areas surrounding three of these establishments in the east central part of the State. Since many of the war industries in the State are centered in Louisville, malaria control measures are of grave importance in that vicinity. There are, however, other large plants located in the western part of the State at Henderson, Paducah, and Mayfield.

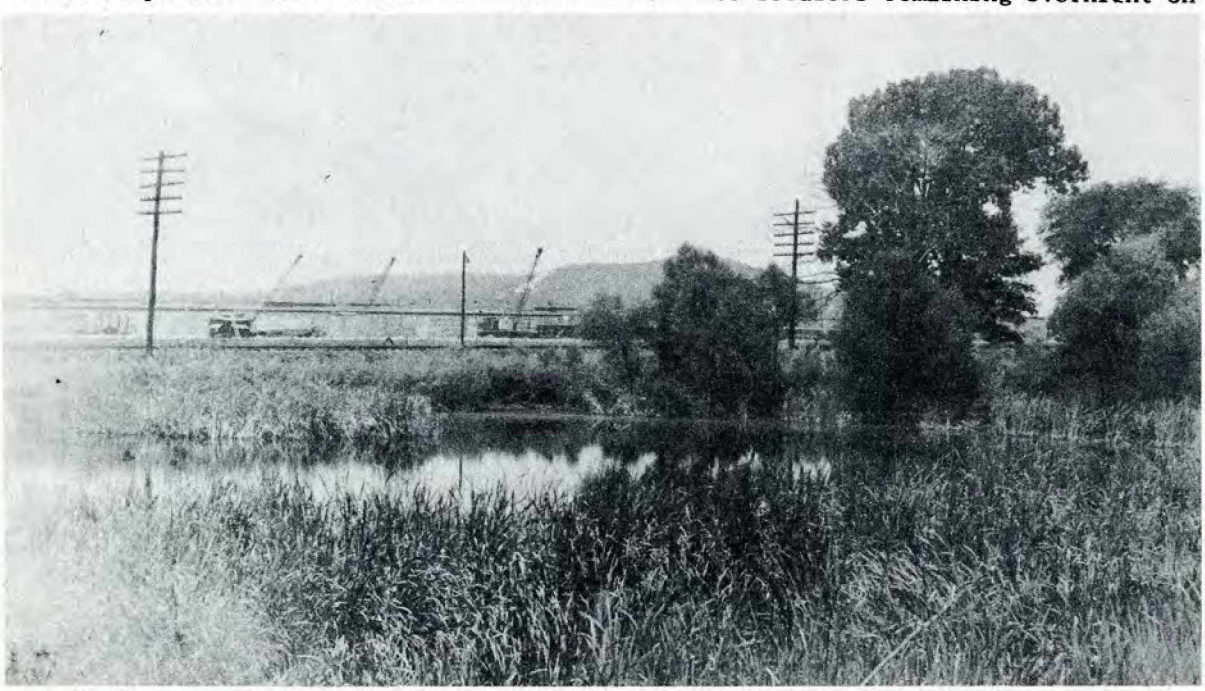
Probably the most effective single control project in the State was completed at West Louisville, where a 75-acre slough was practically eliminated by drainage. The slough was located in a critical position between several large war plants and the neighboring residential areas. In one week last year collections of adult mosquitoes from four stations surrounding the slough showed a total of 164 "*quads*." This was in July 1943 after control measures had been conducted for only one week. Drainage work was carried on during the winter months and to date, June 30, 1944, only two adult "*quads*" have been taken from resting places in the drainage area. The upper portion of the slough is completely dry and in the lower portion water is confined to a freely flowing channel.

Data on "*quad*" breeding in the war areas indicate a somewhat earlier appearance of larvae in 1944 than occurred in the preceding year, particularly in the Paducah zone. "*Quad*" larvae were found in abundance early in May in backwaters caused by the flood conditions of the Ohio River. Intensifying inspection and supplementing the labor crew with workers from the nearby Mayfield zone prevented the development of these larvae into adult mosquitoes. The backwaters were thoroughly inspected and immediately larvicided, and the adult "*quads*" never appeared in the natural resting places in large numbers.

The employment of new laborers proved quite difficult in the early part of 1944. Young men are not available for the work, and many of the older men refuse employment because the work is too strenuous. The inspection force, however, has been filled with men of very high caliber--graduate college students and high school teachers. The generally high quality of these men has been of great value in accurately determining the sources of "*quad*" breeding.

In the city of Elizabethtown the local government contributed approximately $700 in the form of power equipment, materials, and laborers, while the MCWA program furnished technical supervision and a part of the labor crew. In this case a 1500 foot winding ditch was relocated; 600 feet of it was lined with concrete; approximately 100 feet were piped; and the balance was of open earth construction with sloping banks.

New zones have been added recently at three of the army camps to afford protection for soldiers remaining overnight on



Anopheles quadrimaculatus Breeding Area Near a War Establishment

"Quads" Breed in Emergent Vegetation

firing ranges. These new zones have increased the areas under surveillance and control by approximately 45 square miles.

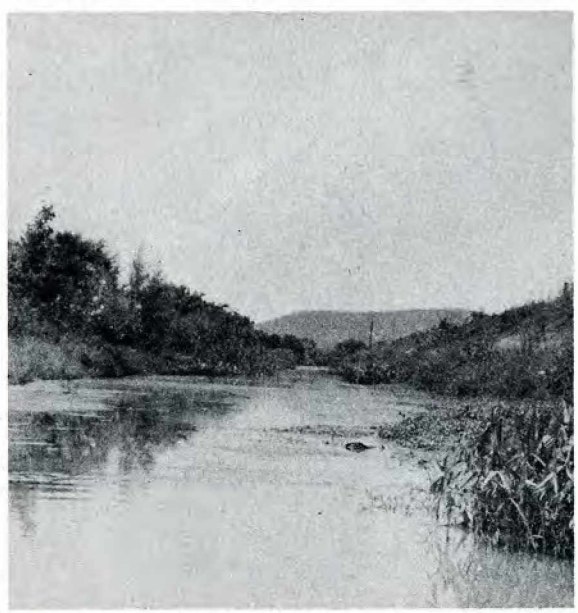
In all of the war areas the control of breeding places has been performed entirely with hand operated oiling and dusting equipment. Scattered small-size breeding places make the use of power equipment impractical. The high quality of the inspection force permits larviciding to be limited to those locations where "*quad*" larvae are actually found. This practice enables the program to operate with fewer larviciding crews, thus effecting a saving in both materials and manpower.

In the war areas most of the drainage work was completed during the winter of 1942-43. However, major drainage projects were in operation in three of the areas during the winter of 1943-44. In the Paducah area one of the major drainage projects could not be completed due to the extended period of flood conditions prevailing in the early spring; and the shortage of manpower, coupled with the early abundance of "*quad*" breeding, prevented completion of the project after the flood waters receded.

The State Department of Health rendered technical assistance to a special course in malaria control which was conducted at the Murray State Teachers College. The purpose of the course was to acquaint teachers and county sanitarians with the general procedures of such a control program.

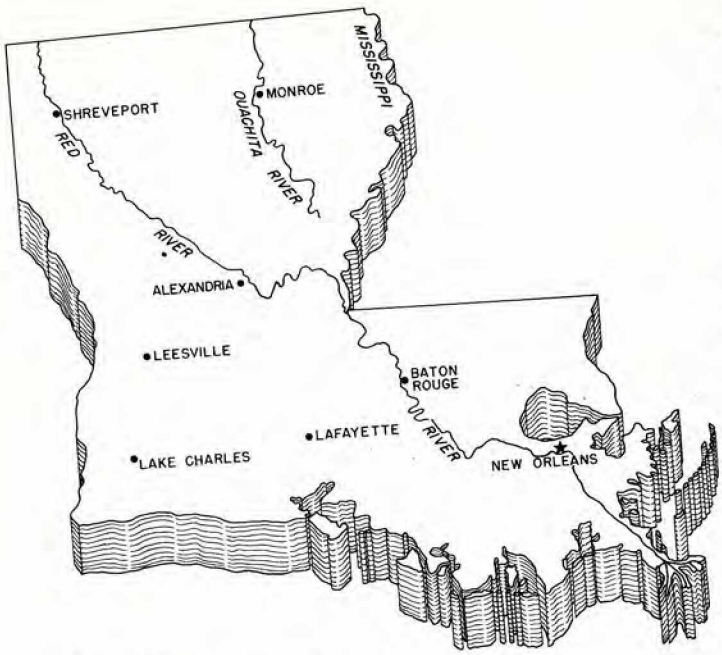
The course was inaugurated for the particular benefit of the teachers and sanitarians in the counties bordering the new Gilbertsville Dam. The class was attended by approximately 60 men and women, and field trips and laboratory work comprised a vital part of the studies.

Another educational project of the State Department of Health was conducted at Louisville where approximately 140 medical and dental students from the University of Louisville were shown the field methods of inspection and control in the Louisville area. This field trip is part of an annual program in which the medical and dental students of the University of Louisville are shown the operations and procedures of the entire State Department of Health.



A *quadrimaculatus* Breeding Area

LOUISIANA



The entire State of Louisiana is within the area of endemic malaria along the Gulf Coast. Where the salt water reaches inland, however, large areas have never been seriously afflicted with malaria.

During the fiscal year 1943-44, malaria incidence was the lowest on record. Most of the cases occurred in the northern half of the State where sluggish streams in the delta areas and seepage flats along the banks of the streams in the rolling uplands constitute topographical features which contribute to anopheline breeding.

PRESIDENT, BOARD OF HEALTH
DAVID E. BROWN, M.D.

DIVISION OF PUBLIC HEALTH ENGINEERING

STATE OFFICE M.C.W.A.

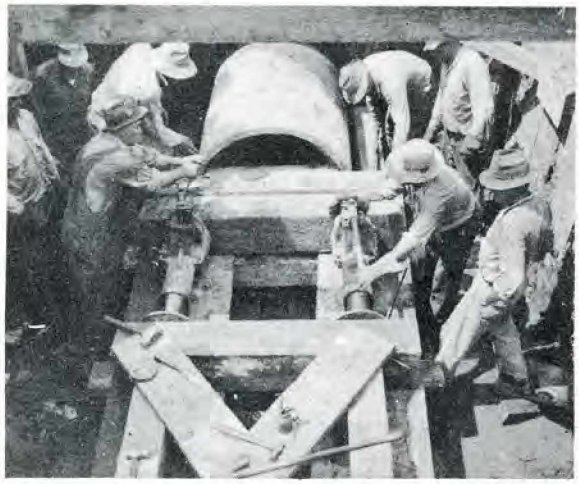
8 WAR AREAS
90 WAR ESTABLISHMENTS PROTECTED

The Valleys of the Red and Ouachita rivers, and their tributary bayous running north and south, continue to furnish *A. quadrimaculatus* breeding areas and have the highest rate of malaria cases in the State. All but one of the Army training camps in the State are located within this critical area. The camps and airfields located in the vicinity of New Orleans, Lafayette, and Lake Charles are relatively near the Gulf, where vector breeding is lessened by the occasional presence of salt water. However, the malaria vector breeds in surface waters in sufficient numbers to require close watch and control at all times to guard against increased malaria incidence. The area occupied by camps and airfields near Baton Rouge is high and easily drained.

Most of the control work during the breeding season was carried on by the use of larvicides, with No. 2 fuel oil as the principal larvicide. Approximately 700,000 gallons of this oil were spread during the season.

It was found that breeding in an 800-acre swamp near Jackson Barracks could not be controlled by hand oiling or hand dusting. When the zone was dusted once a week by airplane, 90% control was obtained; but the remaining numbers of "*quads*" were sufficient to present a serious problem to the Barracks. It was decided, therefore, to drain the swamp, which was kept flooded by wind tides. A levee two miles long and six feet high was constructed along the south bank of Bayou Bienvenue. A culvert was built through the protection levee railroad embankment on the south side of the swamp, thus connecting the swamp with a low-level canal. A tide gate was installed on the swamp side of this culvert as a precaution in case the levee should break at any time and overload the city pumps. The city of New Orleans is handling the water at its No. 5 pumping station free of charge.

To facilitate quick surface run-off, a series of drainage ditches was constructed by dynamiting. This project has just been finished and put into operation.



Jacking a Culvert at Jackson Barracks

Early results indicate that it will be completely successful where all other measures failed.

At Lake Charles 1000 acres of rice and at Alexandria 300 acres of rice were dusted by airplanes during the breeding season. About one pound of paris green per acre per dusting was used each week. Control was accomplished in the "A" stations of the Alexandria zone, but numbers of "*quads*" were found in the "A" stations at Lake Charles even though it was estimated that the dusting was 90% effective.

Small quantities of some other larvicides were used, such as 12 coefficient phenol in a 1 to 24 solution in water. Very small quantities of proprietary sprays were used on a few ornamental pools.

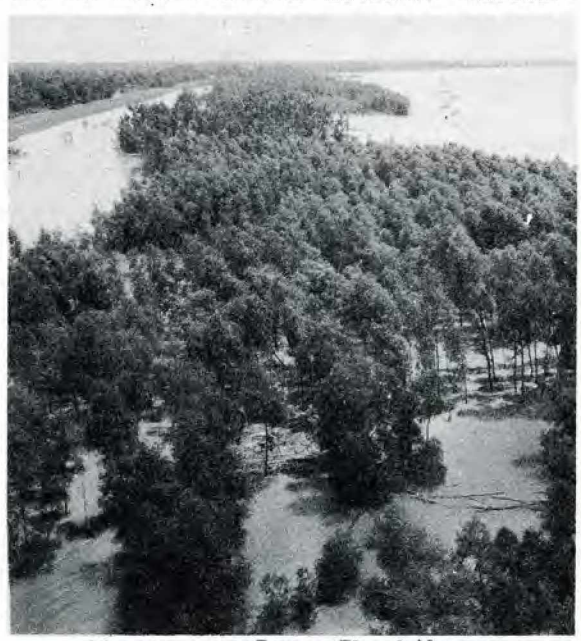
Normally the larviciding season closes in Louisiana on November 1 of each year except in the areas of New Orleans, Lafayette, and Lake Charles, where some larviciding and inspection are required all winter.

During the winter period, from November 1st to May 1st, the minor drainage program was continued from the previous season and resulted in the elimination of large areas which formerly required larviciding. Minor drainage installed during the winter effected a saving of 89 men in the State when the larviciding season began.

In Louisiana, it seems that emphasis should be placed on drainage, both minor and major, as a prime control measure, because of the results achieved in all areas by well considered and executed drainage programs.

This office is inclined to agree with the arbitrary limit of ten adult female "*quads*" in "A" stations as a measure of effective anopheline control. However, during May and June flood conditions back up the waters of the Red, Ouachita, and Mississippi rivers and their tributaries. At this time large areas of the flat countryside are inundated. Tremendous numbers of "*quads*" are produced and what is ordinarily considered as adequate "*quad*" control is not economically feasible. But the number of human carriers during the winter is so low under present conditions that the disease does not build up to serious proportions before adequate anopheline control is effected. Therefore, the scope of normal operations has not been increased in an attempt to meet this seasonal problem in the absence of any indication of local malaria transmission.

In this State, the large areas of flat marshy ground with shallow water and extruding grasses are difficult to larvicide. Such areas may be doubled and quadrupled in extent by only a small vertical rise in the water level and by only one rain. The areas are usually wooded to such an extent that it is impossible to use mechanical control methods. Further-



Mississippi River Flood Waters

Constructing Levee with a Dragline

Breeding Conditions in Swamp

more, the overhead verdure is usually too thick to let in dust spread from airplanes. Therefore, it is necessary to oil these areas by hand. It has been found by experience that this type of place is a continuous breeder and must be oiled once each week during the entire breeding season. Ten to twenty men with pump sprayers line up about five yards apart and move forward in a line until the zone boundary is reached, then the line moves over and comes back, covering another strip. This maneuver is repeated until the entire area is covered.

A glance at the acreage controlled and the amount of larvicide used will give some idea of the magnitude of the physical job necessary to obtain any control in

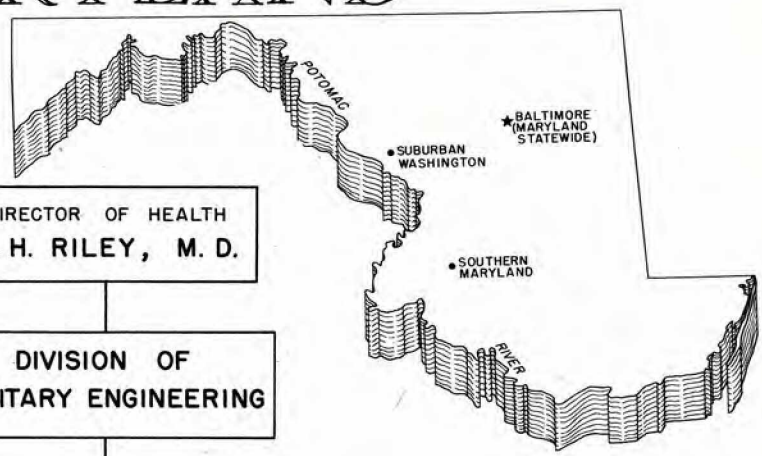
Dipping for Larvae in Flood Waters

Ditch Cut Through Matted Vegetation

many of the zones in Louisiana. During the last season of twenty weeks when normal larviciding operations were carried on, a total of 42,400 acres were treated with oil, using 706,500 gallons of oil. During the maximum month of this period 6,832 acres were oiled using 117,500 gallons of oil, or a coverage of 1,708 acres each week, using 29,325 gallons of oil in each coverage.

There has been little malaria reported in the State during the year. Cases reported from military establishments usually have been due to infection at points outside our protected areas, according to the reports of Army surgeons.

MARYLAND



DIRECTOR OF HEALTH
R. H. RILEY, M. D.

DIVISION OF SANITARY ENGINEERING

STATE OFFICE M.C.W.A.

3 WAR AREAS
32 WAR ESTABLISHMENTS PROTECTED

Maryland is on the northern border of the malaria belt, and the disease has not been an important public health problem for almost 20 years. However, the presence of large *Anopheles quadrimaculatus* breeding areas in close proximity to some of the important war establishments where numerous malaria carriers are concentrated has required that control work be carried on in spite of the absence of active malaria transmission.

Growth of water chestnut in the Potomac River provided thousands of acres of "*quad*" breeding surface within mosquito flight range of Army and Navy establishments. During the latter part of the fiscal year, the water chestnut was eliminated by cutting and by manual removal work done principally by the U. S. Engineers and the Navy Department, with some assistance from MCWA and private property owners.

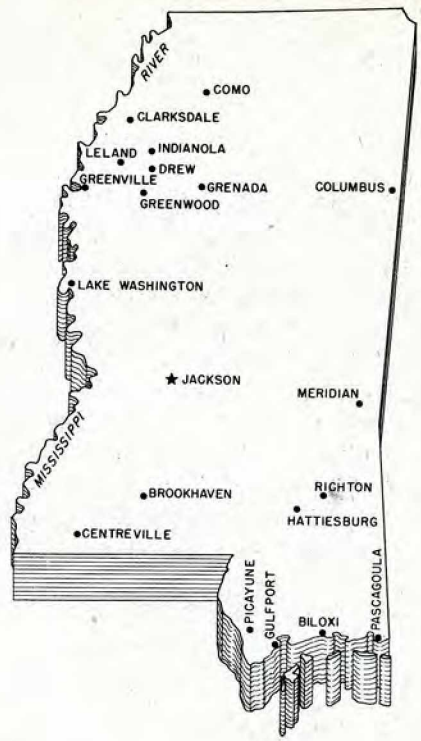
Cutting Water Chestnut Plants

Careful coordination of the entomological inspection service with control operations has made possible considerable economy in manpower and materials. Larviciding is strictly limited to "*quad*" breeding places and is not started until adult counts of significant magnitude have been found in "A" stations, or until adjacent areas show high larval populations.

In addition to four zones where control work is done, inspections are carried on around some 25 other establishments. Ten of these were inspected or surveyed during the 1943 breeding season. Four prisoner-of-war camps, one general hospital, and several other stations with considerable numbers of troops recently returned from malarious areas overseas, are among the 25 establishments. Fortunately, most of them are located in areas where "*quad*" breeding is relatively light. However, some control work may be necessary at four or five of these places.

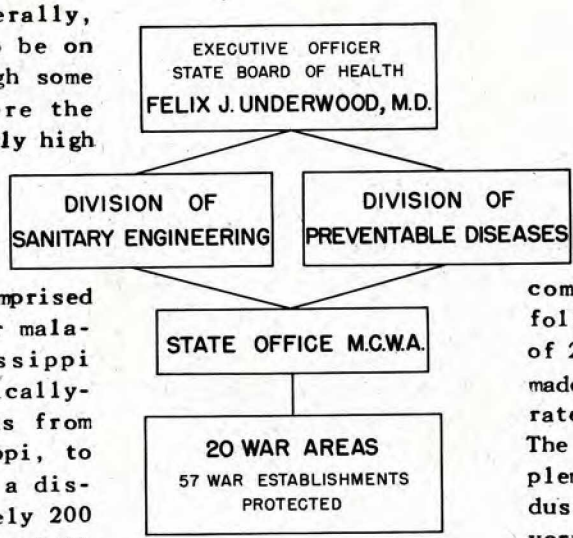
A school for training inspectors was held during May. Several Army and Navy personnel engaged in mosquito control work on their respective stations attended this school.

MISSISSIPPI



During 1943, fourteen active areas afforded malaria protection to fifty-four war establishments in Mississippi. The current 1944 season has necessitated a considerable increase in activities, and probably still greater efforts will be required to provide control for numerous prisoner-of-war branch camps being established in areas of extreme labor shortage.

Present knowledge of the malaria problem has made it appear necessary to carry out active control measures in all areas established under the MCWA program, although some are considered of much greater importance than others, and a few zones are requiring only inspection and a watchful eye.



In the State generally, malaria is known to be on the decline, although some sections remain where the incidence is relatively high The most clearly defined geographical section in the State, and one which has long comprised an endemic focus for malaria, is the Mississippi Delta. This elliptically-shaped plain extends from Vicksburg, Mississippi, to Memphis, Tennessee, a distance of approximately 200 miles. Its greatest width is 85 miles. Army air bases in the region of Greenville, Greenwood, and Clarksdale have been the scenes of the program's most difficult problems and most intense endeavors to date.

Airplane dusting of Archer Island at Greenville was again necessary this season. The Mississippi River reached its peak of nearly 42 feet more than three weeks earlier than in 1943, and as a result flood water covered this heavily wooded island. Abundant logs, flotage, and emergent vegetation provided ideal "*quad*" breeding over more than 600 acres. Control by airplane dusting had proved only partially effective in 1943 because of the thick undergrowth and tall trees. In 1944 increased amounts of paris green were used per acre to compensate for the heavy foliage. Two applications of 20% paris green dust were made by airplane dusting at a rate of two pounds per acre. The first applications, supplemented by hand and power dusting from boats, proved very effective.

The following week saw the water receding, and an attempt was made to limit the second application to the remaining lakes and sloughs. These results were spotted and unsatisfactory. It was concluded that (1) airplane dusting can be very effective even in overgrown wooded areas, provided the rate of application is increased to compensate for heavy foliage, and (2) precision dusting of relatively small individual bodies of water from altitudes necessary to clear tall trees may not be feasible due to lack of control of the dust

cloud or excessive spread of the dust path.

During the last few years an exodus of agricultural workers from the Delta has resulted in planters' contracting for a large number of prisoners of war. P.O.W. camps are being constructed in eight different localities. Malaria control operations in this connection bid fair to relegate previous MCWA Delta activities to a minor role. Practically all of these branch camps are located on or within easy flight range of bayous, which require drainage as a control measure.

Great importance is attached to the need for malaria control in the Delta, but the fact remains that climatic conditions throughout the entire State are favorable to the development of the *Anopheles* mosquito, and ecological factors favor the principal vector, *Anopheles quadrimaculatus*, in all but the Gulf coast region.

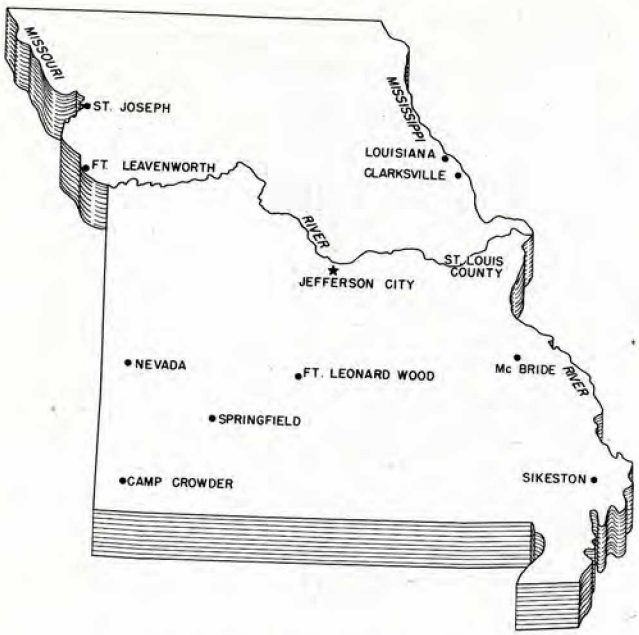
The largest MCWA area in the State is Grenada No. 11. In addition to control around the Air Base and in the City of Grenada, 28 square miles are under control adjacent to Camp McCain. Here an unusual situation was observed in 1943 and during the present season. Large numbers of adult "*quads*" occur under highway bridges located on the camp boundary, which serve as adult index stations for both Army and MCWA programs. Other natural resting places seem to indicate reduced numbers of "*quads*" away from the highway, both on the reservation and in the extra-cantonment area. High percentages of adult males seem to indicate nearby breeding. However, intensive searches by Army and MCWA personnel have failed to locate any breeding areas capable of producing such numbers within a mile. It has been observed that in this and other areas some natural resting places have particular attraction for "*quads*."

Airplane Dusting of Archer Island

Curing Period for a Lined Ditch

The problem of providing trained inspectors was attacked by establishing a training organization. Inspectors have been appointed in Jackson, trained by State Office personnel, and given field experience with crews working around various military installations. As the trainees became adept, they were assigned to full responsibility as inspectors when the need for such employees occurred. A reorganization, involving the forming of two sectional offices, has served to simplify and to decentralize some of the numerous administrative details formerly confined to the one State Office in Jackson. Concrete benefits have been observed as a result of work by malaria educators. Results include a greater understanding of malaria control by the general public and better cooperation by private land owners.

MISSOURI



During the year 1943, control operations were carried on in the following areas in Missouri: St. Louis County, Fort Leavenworth, Louisiana, McBride, and Springfield. Projects involving inspection only were instituted at the Fort Leonard Wood Area and at Camp Crowder.

Malaria has been endemic in the Sikeston area in southeast Missouri where two airfields are being protected--one at Sikeston, the other at Malden--but the disease has followed the general downward trend apparent throughout the county.

This section of the State, formerly known as "Swamp-east Missouri," has been drained for agricultural purposes and the breeding area for *Anopheles quadrimaculatus* is confined, for the most part, to sluggish ditches which become heavily vegetated during the summer. One of the problems which arose in this area, particularly during times of high water, was caused by patches of *Ceratophyllum* breaking away from ditch banks and floating downstream, carrying *quadrimaculatus* larvae and pupae into the control zone. This situation was controlled by erecting an intercepting fence at the upper limits of the mile-zone and cleaning the fence at regular intervals.

In the St. Louis area 16 cases of malaria were reported in 1943 from both city and county, which is not surprising in view of the dense population. The Jefferson Barracks Zone is unique in the large number of lime sinks present within the control limits. Ninety-two of these sinks hold water at least during part of the year, and some hold water all summer. The largest of these, known as the "Lemay Sink," is located north of the Barracks and was controlled by vertical drainage early in the year.

Control work was also carried on around Kratz Field and Lambert Field, in the northern part of the county.

STATE HEALTH COMMISSIONER
JAMES S. STEWART, M.D.

DIVISION OF ENGINEERING

STATE OFFICE M.C.W.A.

10 WAR AREAS
33 WAR ESTABLISHMENTS PROTECTED

Malaria is not considered a problem by health officers in the Fort Leavenworth area. However, there are large populations of *Anopheles quadrimaculatus* in the extracantonment zone and it is necessary to operate a preventive program there. During 1943 a number of East Indian troops were encamped on the post, many of whom were from endemic malarious areas.

A major drainage project which would drain almost all of the area now being larvicided on the Missouri side of the river is partially completed. This flood plain produces tremendous numbers of *Aedes* and *Psorophora* in the early part of each year, but the silty character of the soil prohibits any method of larviciding except by plane. Anopheline control is also difficult because of the mud and silt but, since control for anophelines is not inaugurated until sometime in May, the footing becomes sufficiently firm to permit entrance to the zone.

Lemay Sink before Drainage

Construction of Drain

The water in the Louisiana area has been impounded by the Clarksville Dam, and local physicians state that the incidence of malaria has increased since 1938, the year the dam was built. Quoting from the Interstate Malaria Survey Reports for the years 1940 and 1941:

Questioning local physicians in Louisiana revealed that there was a total of approximately 150 malaria cases. These cases were confirmed, for the most part, by laboratory findings. A house to house survey of an area at the edge of Louisiana and along the river was made. A total of 26 houses, in which 132 persons lived, were visited. The financial, social and hygienic conditions of the families were poor. A total of 21 persons reported that they had malaria this year. Nine of these cases were confirmed by blood examinations in our laboratory.

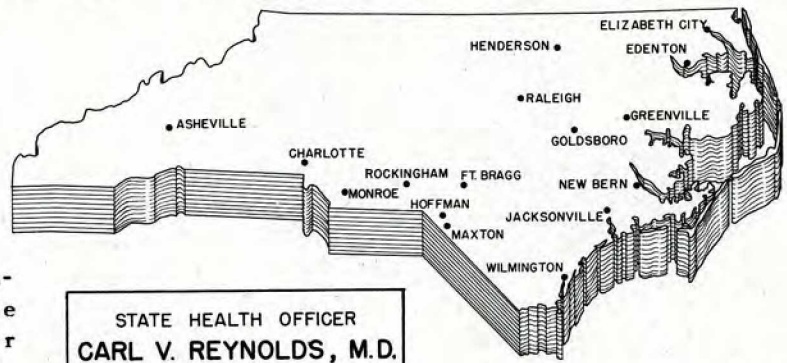
Clearing Rocks from Vertical Drain

The Camp Crowder area, including the town of Neosho, is rolling and well drained, and malaria is not a problem in this section. A small larvicidal project has been instituted in Neosho, which has military importance because of its proximity to Camp Crowder.

The Springfield area is also rolling and well drained with the exception of one large sink near the Frisco Shops, which has a water surface of approximately 30 acres. A poor economic section exists in the immediate vicinity, and local health officers state that practically all the malaria in the vicinity of Springfield has been reported from this section.

Regular inspection projects at Rosecrans Field, St. Joseph, and Fort Leonard Wood did not indicate the necessity for beginning control operations. Some fairly high adult counts were recorded at Rosecrans Field, but they were taken in what would be the "D" or "E" sections of our control zones. At Fort Leonard Wood, in the Ozarks, very large numbers of anopheline larvae may be taken in the cool mountain springs and streams, but upon examination the large majority of these are found to be *Anopheles punctipennis*. *Anopheles barberi* has also been taken in this zone.

NORTH CAROLINA



STATE HEALTH OFFICER
CARL V. REYNOLDS, M.D.

DIVISION OF EPIDEMIOLOGY AND VENEREAL DISEASE CONTROL

STATE OFFICE M.C.W.A.

15 WAR AREAS
89 WAR ESTABLISHMENTS PROTECTED

North Carolina has conducted a malaria parasite survey since 1937. Over 75,000 slides have been taken, giving the State an excellent record of the location of most malaria foci. Continuous use has been made of these data to evaluate the malaria hazard in vicinities of war establishments operating in North Carolina. The information gained from the slide survey was used, whenever possible, to influence the location of such war establishments.

During the past year, the War Manpower Commission and the War Department have agreed that each proposed prisoner-of-war camp site must be approved by the State Board of Health. As a result of this arrangement the camps have been placed in areas where there is no serious malaria threat; thus, malaria control work around P.O.W. camp sites has been very limited in extent.

The most difficult control problem in the State at the present time is in the vicinity of Williamston P.O.W. Camp which was established in a malarious area before the system requiring State approval was inaugurated. It is extremely doubtful if adequate control can be obtained for this area without the expenditure of an unreasonable sum of money for drainage, larviciding, and additional construction work.

When the malaria control program was initiated, the policy was to do control work in all areas where there was a probable malaria hazard. By utilizing inspection service to full advantage, it has been possible to discontinue control work in three whole areas of North Carolina, as well as in several zones in other areas. Of course, all of these areas are maintained under surveillance in order that no sudden outburst of "*quad*" production will slip by unnoticed.

An unusual malaria control problem has developed in the vicinity of Asheville, in the most mountainous section of the State, where malaria would not ordinarily be expected. Because it is so far from other control activities in the State, special arrangements have been made with the Army authorities to do the small amount of con-

Constructing Ditch with Hand Labor

trol work necessary outside of the cantonment area. The City of Asheville has agreed to control breeding in a nearby recreational impoundment lake. Thus, the need of setting up an expensive control area has been eliminated.

In the New Bern area a difficult control problem was encountered in the low marshy area subject to tidal fluctuations. It is impossible to drain this area, but by digging broad, flat ditches in these marshes it was possible to permit the free ingress and egress of tidal water, giving very good control of "*quad*" breeding.

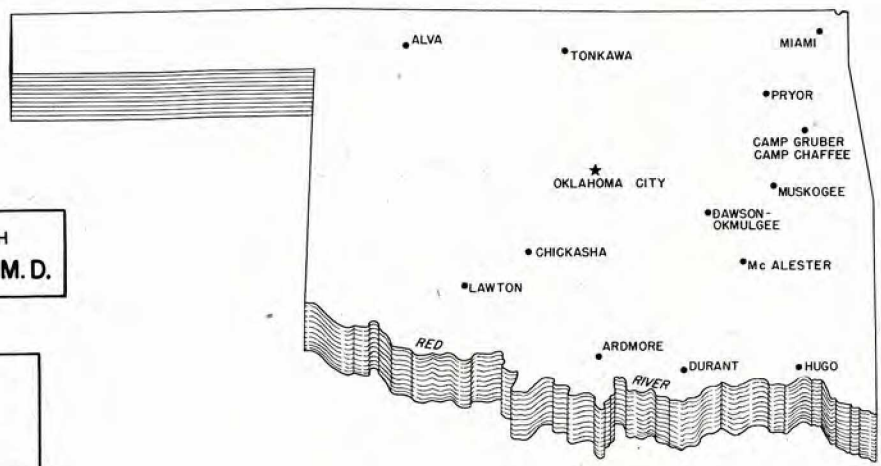
The Elizabeth City area, with well over 125 miles of flat ditches, presents another difficult control problem. Although satisfactory control was obtained over a major portion of this area, adult densities in one section remained high throughout a considerable part of the breeding season. No single heavy production area was found, but there were numerous small breeding areas in ditches adjacent to the station. Satisfactory control has been obtained by placing special emphasis on keeping all ditches clean and free of standing water.

Removing Stump from Ditch Bank

Dragline in Operation

Dragline Ditch Completed

OKLAHOMA



COMMISSIONER OF HEALTH
GRADY F. MATTHEWS, M.D.

BUREAU OF PUBLIC HEALTH ENGINEERING

STATE OFFICE M.C.W.A.

14 WAR AREAS
72 WAR ESTABLISHMENTS PROTECTED

In Oklahoma, the incidence of malaria decreases from the fringes of the Ozark Plateau and Gulf Coastal Plains on the north and southeast to the Gypsum Hills and High Plains of the extreme west as the annual precipitation lowers from 40-50 to 20-30 inches and as the general elevation increases from 500-1000 to 2000-4000 feet. High temperatures and hard winds are characteristic of the State but are most significant in effect on the arid western plains, which are largely unsheltered by forests or hills.

Suitable breeding places for malaria mosquitoes are thus most evident in the crescentic area broadly covering the southeastern corner and extending in one direction to the extreme northeast corner and in the other direction half across the southern border along the Red River. To the swamps, marshes, ponds, pooled streams and bayous of this large area must be added numerous impoundments. These range in size from pasture ponds to huge lakes, one with a shore-line in excess of 1200 miles. The numerous brushy shallows and inlets thus formed have added considerably to anopheline production.

Many of the Oklahoma war areas fall within this generally malarious area, but the local situation is often much less alarming than the total picture. The policy has been to effect an economical program of control by concentrating on exact foci of production which have been discovered through preliminary surveys and inspections.

The Malaria Control Program in the State of Oklahoma has been increasing in size due to the establishment of prisoner-of-war camps and hospitals. A survey has been completed around each war establishment, and those which show *Anopheles quadrimaculatus* in sufficient numbers have been placed under control. Others are under regular inspection in a survey program that has been extended as new prisoner-of-war camps have been established in various parts of the State.

Two very economical drainage projects have been completed during the past year.

A 40-acre lake at Hugo was eliminated by cutting through a dam, and a 15-acre lake at Durant was removed by opening a tile drain.

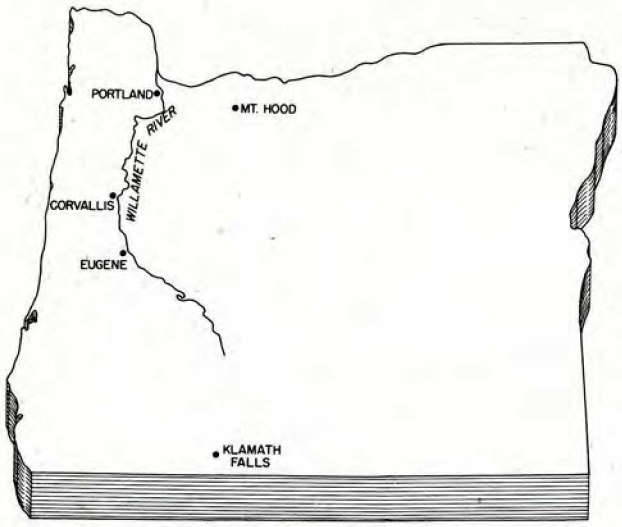
Last winter the program consisted of revising maps in some of the areas which were operated during the previous year and preparing maps and estimates in new areas. Surveys were completed in thirteen towns, cities, and war establishments where it was probable that control work would be needed this year. Information for each zone was collected in order that project proposals could be made. Labor, equipment, and materials needed were computed for each project, and a summary of the problem with recommendations for control were submitted in narrative form. In addition, forms were devised which contained questions for local doctors and druggists in order that information might be obtained on the number of malaria cases treated and the amount of anti-malaria drugs sold.

A "sectional method" of reporting larval collections is now on field trial in Oklahoma as an innovation in area inspection which offers advantages in simplicity, usability of data, and exact correlation of inspection and control routines. In brief, this method requires an accurate field map showing land sections and all water bodies. Collections are made in routine circuit to cover each section completely through no more than one month, and at least one quarter of each section through each week. The actual land section number, used by the foreman in directing the crew, is used as the station number, followed by NE, NW, SE, or SW to indicate the quarter-section, and by the standard letter indication of actual distance at which the collection is made. Under "Locations or Remarks" on the Standard Report Form, the nature of the breeding place is given. This method binds the area inspector to routine responsibilities, yet invites extensive exploratory trials. At the end of the season results of inspection can be correlated exactly with the materials and labor of control.

Breeding Places before Drainage

Breeding Places Eliminated by Drainage

OREGON



Oregon has a long and very interesting history of malaria. The disease was so prevalent prior to 1845 that the original settlement of Portland was abandoned.

The state is traversed from north to south by the Cascade Range, which extends from Mt. Hood near the Washington line to Klamath Falls in the south. A little less than one-third of the State lies west of the range. This is a well watered expanse of rolling hills with extensive forested areas interspersed with cleared areas devoted to agriculture and industry.

Midway between the Cascades and the ocean is the Willamette River. It is formed by a number of tributaries near the city of Eugene and flows north to join the Columbia at Portland. Its valley, which is devoted to intensive agriculture, is the sole remaining focus of malaria in the State.

Anopheles freeborni, the western malaria vector, is sporadically distributed over the entire State but builds up to heavy densities in the Willamette Valley in the late summer. The control problem here is not difficult but requires painstaking, detailed work. The Valley floor is relatively narrow, with many seepage areas resulting from the nearby hills. These are prolific sources of *freeborni* breeding. Densely shaded sloughs of the river furnish admirable *punctipennis* breeding places but, fortunately, little *freeborni* breeding has been discovered in these areas.

The malaria that has occurred in recent years has been largely of an epidemic type and has been localized in small areas where human carriers have found employment in temporary agricultural labor camps. Surveys of civilian communities near Camp Adair at Corvallis last winter disclosed the presence of occasional histories of attack.

HEALTH OFFICER
FREDERICK D. STRICKLER, M.D.

BUREAU OF SANITARY ENGINEERING

STATE OFFICE M.C.W.A.

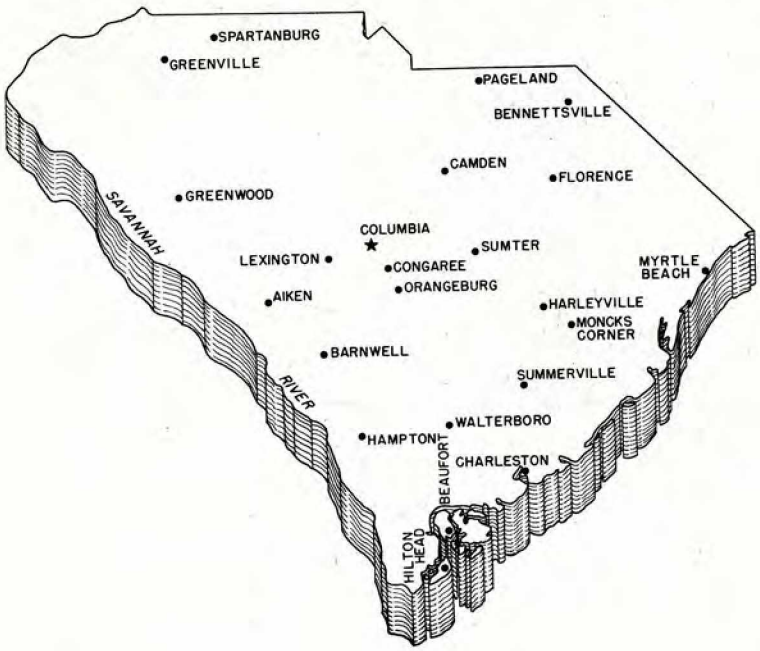
I WAR AREA
7 WAR ESTABLISHMENTS PROTECTED

Camp Adair was the only war establishment in the State where extra-cantonment control work was undertaken last year.

Surveys at Camp White, near Ashland, toward the end of the fiscal year disclosed concentrations of both *freeborni* and *occidentalis*. The latter penetrates farther inland in Oregon than it does in California, aided, no doubt, by the topography and the cooler, relatively moister interior climate. Steps are being taken to institute control of *freeborni* at Camp White.

Breeding Place of *Anopheles freeborni*

SOUTH CAROLINA



STATE HEALTH OFFICER
BEN WYMAN, M.D.

DIVISION OF PREVENTABLE DISEASES

STATE OFFICE M.C.W.A.

24 WAR AREAS
122 WAR ESTABLISHMENTS PROTECTED

Malaria is endemic, widely distributed, and probably the leading cause of morbidity in most of the southeastern half of South Carolina although it occurs in all parts of the State. Anopheline mosquito breeding places in the southeastern part of the State are found in swamps, abandoned or overgrown farm drainage canals and ditches, abandoned and overgrown phosphate mining strip pits, many natural depressions, limestone sinks, undrained highway borrow pits, and roadside ditches.

The sandhill section, about 15 miles in width, extends across the center of the State from the Savannah River on the southwest to the North Carolina line on the northeast. There are many natural highland ponds throughout this section but the chief breeding places for anopheline mosquitoes are the many small artificial ponds, narrow swamps along the streams, and abandoned brickyard clay pits in Aiken and Sumter counties. Malaria is of low endemic incidence in this section.

The remaining topography of the State varies from gently rolling hills adjacent to the sandhill section to mountains in the northeast. Malaria in this area occurs as small explosive epidemics geographically limited almost entirely to the vicinities of artificial ponds and lakes.

Extensive thick blood film malaria surveys throughout the State during the past seven years have enabled the State Board of Health to locate known foci of malaria. This information was not utilized in the establishment of many new Army and Navy bases, but it was of great value in determining the kind and amount of control to be done by the State Board of Health and the U. S. Public Health Service.

Although fuel oil was the chief larvicide used, paris green was utilized in 12 of the 24 areas and kerosene was employed on the Orangeburg Fish Hatchery as well as on many small artificial pools.

The chief means of applying the oil and paris green was by hand. However, a power spray boat was used on two large lakes near Fort Jackson and on a large mill pond in Camden. The power spray boat was transferred from one area to the other by truck. In Sumter a power sprayer mounted on a truck was used.

Drainage and Filling. Since the spring of 1942, all but two of the large and difficult "*quad*" breeding places in the 24 control areas in the State have been eliminated. The Jeffries Creek swamp near the Florence Army Air Base, with approximately 910 acres of breeding area, gave very little trouble until the spring of 1944. Due to excessive spring rains or other factors, it has been necessary to dust the greater portion of this swamp regularly since early May. The other large undrained breeding place is in the Charleston area where old abandoned phosphate strip mines, covering approximately 500 acres, have long been a source of heavy "*quad*" breeding. Drainage has not been practicable since many of the mines are below sea level. Control in these pits has been very difficult and not as satisfactory as desired.

During the fiscal year 1944 82.0 miles of major and minor ditches were dug, eliminating 369.43 acres of mosquito breeding surface. Of the above amount, 64.2 miles were constructed by hand labor, 14.1 miles by dynamite, and 3.7 miles by machine. Four acres of mosquito breeding surface were eliminated by filling. Most of the filling was done with a small bulldozer. It is planned to extend this type of control to the Charleston and Beaufort areas where there are a number of small sink holes and bays suitable for filling with a bulldozer.

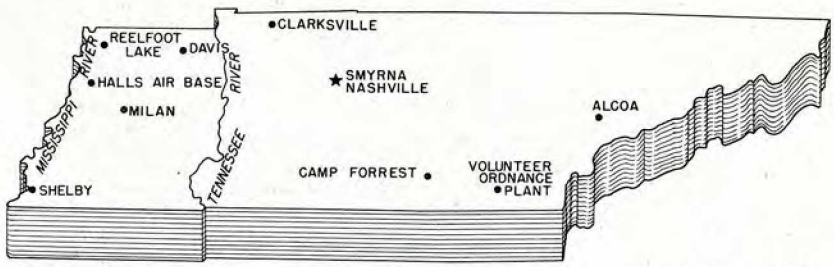
Dynamite Blast

Dynamite Ditch after Blast

Larvicidal work. Drainage work has eliminated many of the known breeding areas, thus reducing the amount of larvicidal work necessary for control in the 290.34 square miles under supervision. Eight hundred thirty-nine miles of ditches were cleared and 1040.1 acres of re-clearing was completed during the year on the larvicidal program to facilitate the larvicidal work and further reduce the amount of larvicide used and to improve the quality of control.

When the malaria control program was first initiated, control work was carried on in the vicinity of all war establishments. Following the collection of extensive entomological data, it was possible to eliminate three areas from active control and place them on an "inspection" basis after the first year, thus saving the cost of control. During the past year one other area was placed on an "inspection" basis after the known breeding areas were eliminated by drainage. In the control areas entomological data were used to limit active control to those places in the area where "*quads*" were breeding. This not only reduced the amount of larvicide used but also the number of men needed for control in the respective areas.

TENNESSEE



COMMISSIONER OF PUBLIC HEALTH
R. H. HUTCHESON, M. D.

DIVISION OF PREVENTABLE DISEASES

STATE OFFICE M.C.W.A.

9 WAR AREAS
159 WAR ESTABLISHMENTS PROTECTED

The malaria problem in Tennessee is primarily in the western section, between the Tennessee River on the east and the Mississippi River on the west. The most serious problem in this region is encountered in and adjacent to the areas subject to the overflow of the Mississippi River. This territory includes the valleys of tributary streams, as well as several smaller creeks, and regions around Reelfoot Lake. The valleys of these tributary streams range from one fourth of a mile to four miles in width. Their lower courses have a fall of only about one foot to the mile. There is also a potential problem in the middle portion of the State where malaria is present in endemic form. *Anopheles quadrimaculatus* is found throughout both the middle and western portions of the State; however, it is much more abundant in the western portion. Malaria has not been a problem in the eastern portion of the State.

There are nine areas in the State consisting of 24 zones in which malaria control programs are being operated. Of these, four areas including 17 zones are located in the western part of the State. There are four zones in addition to the above under surveillance.

Since the MCWA program has been in operation in Tennessee, a considerable amount of drainage work has been done in those areas where it was practical, in

Power Dusting on River

***Quadrimaculatus* Breeding Place**

Installing Precast Lining

order to facilitate larvicidal control. In all cases where it was possible, permanent or semi-permanent types of drainage methods have been utilized. In the Camp Tyson Area, 2.6 miles of underground pole drainage have been installed, practically eliminating several extensive swamps caused by seepage springs outcropping around the base of the hills. As a result of this work, the amount of larvicide used has decreased; thus manpower and material have been saved. Permanent ditch lining construction has been made possible in three areas during the winter months by local sponsors furnishing all materials and the Public Health Service furnishing labor and supervision. One and six-tenths miles of ditches have been lined with monolithic concrete in these three areas.

Considerable difficulty has been experienced in hiring labor in most of our areas. The labor turnover has been so great that some of the areas began the larvicidal season with insufficient personnel to secure efficient control.

Ditch with Precast Lining

TEXAS

STATE HEALTH OFFICER
GEORGE W. COX, M.D.

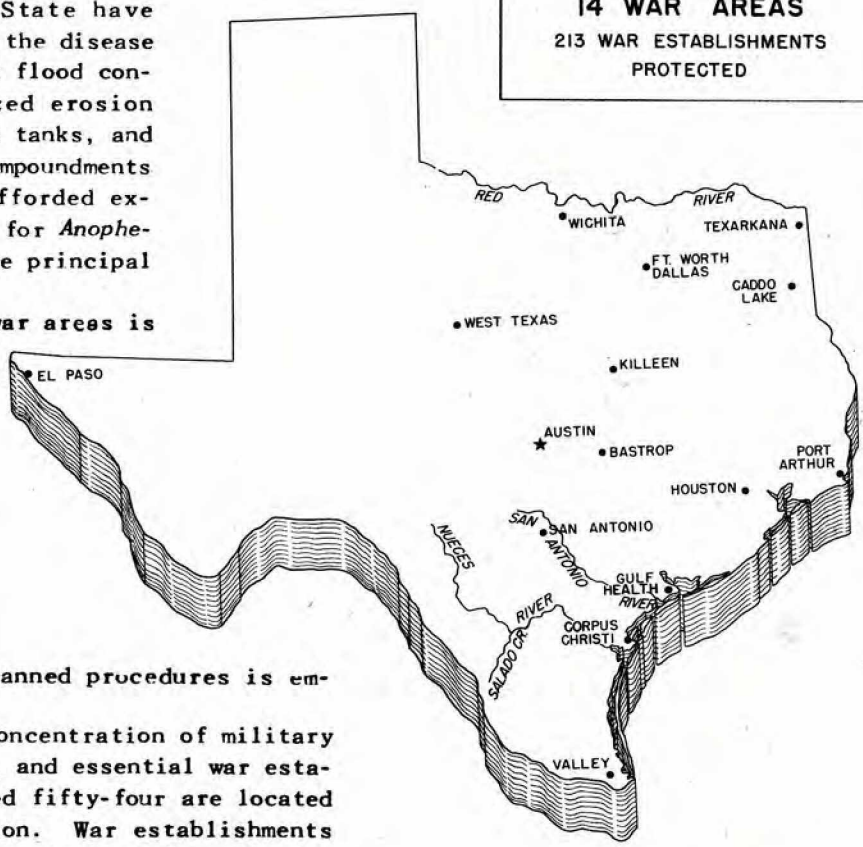
BUREAU OF
SANITARY ENGINEERING

STATE OFFICE M.C.W.A.

14 WAR AREAS
213 WAR ESTABLISHMENTS
PROTECTED

The greater part of the State of Texas is well within the malaria belt of the United States, malaria being recognized and reported throughout the year, with the greatest number of cases occurring from June until October.

The disease is most prevalent in the region lying between the Gulf Coast and a line parallel to it, roughly 150-200 miles inland, except that in East Texas as far as the Red River it approximately parallels the Louisiana border at a distance of 100-150 miles. The more arid portions of the State have been relatively free of the disease until recent years when flood control projects, localized erosion control projects, stock tanks, and numerous construction impoundments were developed which afforded excellent breeding places for *Anopheles quadrimaculatus*, the principal vector.



The problem in all war areas is accurately charted, and rigid control measures are maintained. Control measures that are effective in one area are sometimes impractical in another; therefore, the importance of consistent and well-planned procedures is emphasized.

Texas has a large concentration of military encampments, shipyards, and essential war establishments. One hundred fifty-four are located in the malarious section. War establishments located outside of the malaria belt are under surveillance and can be placed under immediate control if the need arises. Surveys are now being made at the request of the Army for several additional prisoner-of-war camps.

The Counties of Gregg, Smith, Harrison, Bowie, and Morris lie in one of the heaviest malaria areas. Numerous small running streams, lakes, seepage areas, and bottom land swamps caused by overflowing rivers create an acute breeding hazard. Control is obtained by vegetation clearing, small ditch construction, and constant oiling of stagnant areas until water has drained off. Five large drainage ditches were constructed this winter and they should aid greatly in water run-off.

The City of Tyler has contributed labor and equipment. The officials of Camp Fannin, near Tyler, have been very cooperative with respect

to the use of prisoner-of-war labor. Several drainage ditches were laid out by our staff, and good work done by the prisoners contributed a great deal to future control.

In the Rio Grande Valley, particularly in Cameron County, *Anopheles albimanus* is a prolific breeder. This is the only area in the State in which this vector appears. Breeding of both *albimanus* and *quadrimaculatus* is enhanced by the numerous resacas, seepage areas, and many irrigation canals. Good control has been attained by constant cleaning of vegetation, removal of silt from small drainage ditches to prevent clogging, and dusting with paris green. Effective dusting was accomplished with hand-operated equipment.

In the Corpus Christi Area there are quite a number of small marshes and ponds resulting from inadequate drainage. The area is practically at sea level and the soil, which is light sand, is subject to silting and washing. Very good control is being maintained by ditch cleaning and oiling of stagnant ponds until they have been drained off by seepage or new laterals.

The Houston, Galveston, and Beaumont regions have the largest concentrations of essential war establishments in the State. In these areas swamps, marshes, abandoned slush pits, bayous, and numerous drainage ditches occur. A very high annual rainfall, along with poor drainage, adds greatly to the control problem.

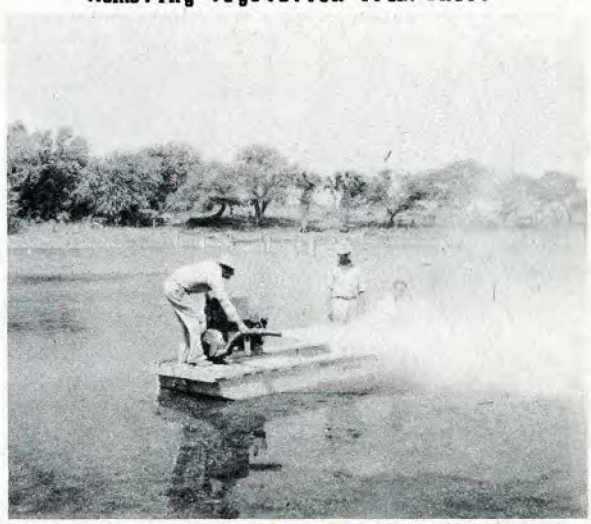
Constant removal of water hyacinths from drainage canals and cattails from marshes is necessary. These operations are supplemented by oiling and dusting. Power equipment has been used to great advantage.

The completion of six drainage ditches has permanently eliminated many acres of swamps and marshes. The terrain is a silty loam. There is practically no silting from run-off as the fall is very low; some damage, however, is caused from torrential rains. The cities and counties of this area have supported the program well.

In the construction of a concrete invert the City of Port Arthur contributed all materials, MCWA supplying the technical supervision and labor. The ditch

Pushing Vegetation to Shore

Removing Vegetation from Shore



Control of *Anopheles* in Aquatic Vegetation

forms an outlet for 16 acres of water and will eliminate all maintenance work. The total cost of materials contributed was approximately $3,200.00

In Brazoria County the Drainage Commission has loaned a bulldozer and two draglines, together with the operators, for the construction of ditches. Technical supervision and other necessary labor have been furnished by this office. This work is a fine example of public-spirited cooperation and will greatly benefit the county.

Bexar County has one of the largest military concentrations in the United States. This area is dotted with numerous intermittent streams, seepage areas, small lakes, and ponds, along with Salado Creek and the San Antonio River. Practically all of the water surface is subject to heavy vegetative growth, and constant cleaning is a necessary control factor, supplemented by larviciding where necessary.

In and around the City of El Paso an intricate system of ditches for sub-irrigation requires considerable maintenance. A large overflow region near the city has been artificially created as a result of straightening tne Rio Grande River. The City of El Paso assists in the control work by furnishing small tools and a truck which it maintains and operates throughout the year.

Sealing Cistern

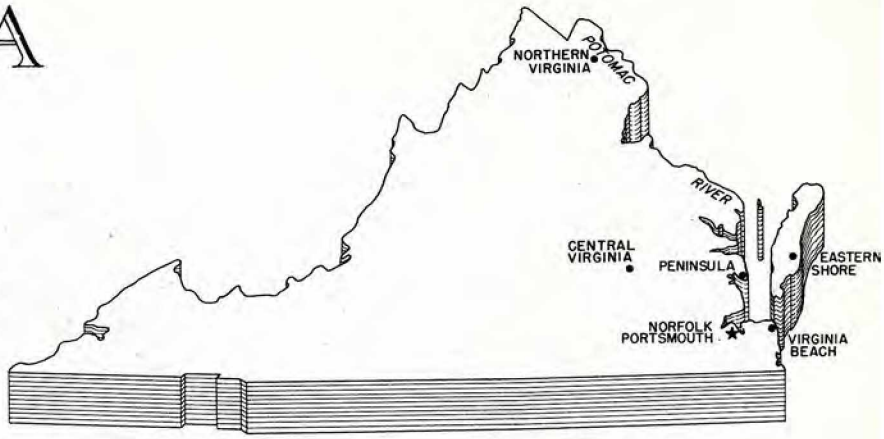
Control of *aegypti* Breeding in Used Tires

Numerous stock ponds, lakes, and tanks are scattered over the Area comprised of Coryell, Limestone, McLennan, and Bell counties. Abandoned gravel pits, and lowlands covered by overflow of the Brazos River, create additional hazards. Drainage is fairly good, but the run-off is very slow because of the flatness of the terrain, making thorough oiling and cleaning operations a necessary practice. Quite a number of borrow pits and abandoned ponds were filled with the excavation from a large drainage ditch near the McClosky Hospital Annex, which was constructed in cooperation with McLennan County. A prisoner-of-war camp near Mexia, in Limestone County, is being controlled by prison labor with MCWA supervision.

Control projects in Corpus Christi, San Antonio, Houston, Galveston, Brownsville, and Hidalgo counties have been most successful in reducing *Aedes aegypti* densities.

The general program has made progress in spite of handicaps, the greatest difficulty being in recruiting labor. Every area in the State has a manpower shortage. However, a fairly adequate force of laborers and inspectors has been maintained. All new inspectors were trained in a five-day course at the State Office Laboratory, which resulted in a definite monetary saving to the Government, since it eliminated the possibility of placing untrained employees on the payroll and having to dismiss them almost immediately.

VIRGINIA



Although the State of Virginia is on the northern edge of the present malarious area of the United States, it has a history of numerous severe epidemics of malaria and a few cases are present most of the time.

Most of the war establishments are located in the Hampton Roads area and along the upper Potomac River near Washington, D. C. There were 106 war establishments under control in Virginia during the 1943-44 season, 81 of which received regular inspection and larviciding. The remaining 25 received occasional inspection only. They are concentrated primarily in the Norfolk-Portsmouth Area and the lower Peninsula Area surrounding Newport News. Because of the heavy concentration of war establishments, the labor shortage has been one of the main problems of the control program.

COMMISSIONER OF HEALTH
I. C. RIGGIN, M. D.

BUREAU OF SANITARY ENGINEERING

STATE OFFICE M.C.W.A.

6 WAR AREAS
106 WAR ESTABLISHMENTS PROTECTED

Although oil has been the chief larvicide used on the program, extensive use has been made of paris green when it was impractical to use oil. New Jersey larvicide has been used in several water impoundments. Almost all of the New Jersey larvicide has been applied with a small power sprayer mounted in a boat. Airplane dusting and cutting operations were used in the control of the water chestnut problem in the Potomac River adjacent to Fort Belvoir and Quantico.

During the winter months considerable drainage work has been completed, totaling 305 miles of ditches cleared, regraded, or installed. This drainage work has had an appreciable effect on the amount of larvicidal control work necessary during the present breeding season. Dynamite drainage has been used extensively since it is very well suited to the mucky soil present in Tidewater Virginia.

In a number of highly developed areas where permanent structures have been built, some ditch lining has been installed in order to eliminate expensive ditch cleaning and larviciding. In the least permanent areas where lining is not economical or feasible, extensive use has been made of ditch cleaning. Clearing work has been carried on quite extensively to make the application of larvicide most effective.

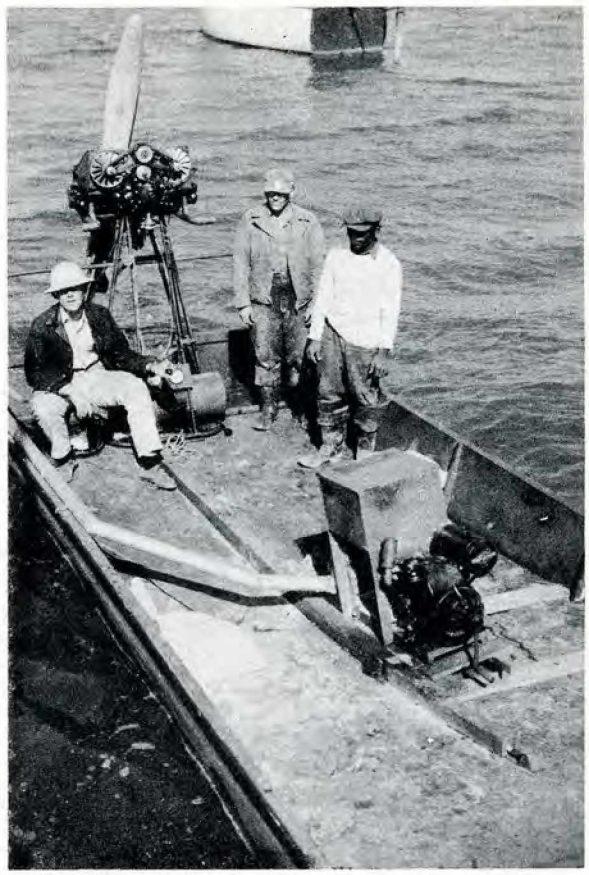
A special control program is in progress in the water chestnut area of the Potomac River. Excellent control was obtained by airplane dusting last year. The United States Engineers have for some years been carrying on a cutting program to eliminate this plant from the Potomac. With the additional under-water cutters furnished by the U. S. Public Health Service, it is hoped that all except a very limited amount of the water chestnut area will be removed from the river this year. Cutting is restricted to the period between emergence of the plants from the water surface

in May and maturity of the seeds in July.

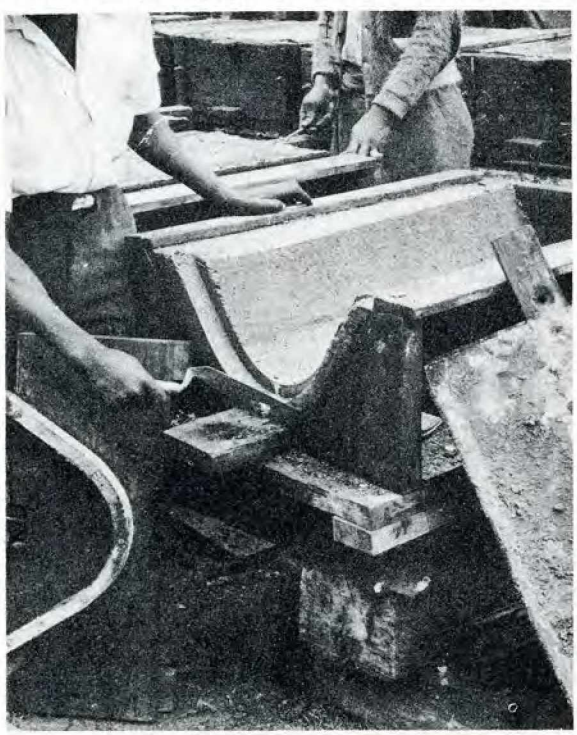
Among the most serious *Anopheles quadrimaculatus* breeding areas in the Norfolk-Portsmouth Area have been six lakes owned by the City of Norfolk. Larvicide has been applied by power sprayers, dusters mounted in boats, and by hand operated dusters from the shores. In general, satisfactory control has been obtained except in the more heavily vegetated coves. Clearing work is in operation on these areas to make larviciding more effective.

In order to relieve the manpower shortage, the malaria control program has made arrangements with the War Department to use prisoner-of-war labor for control around prisoner-of-war camps. If the labor situation does not improve, or if the control problem becomes more difficult, plans are under way to employ prisoner-of-war labor for work in areas other than those immediately adjacent to prisoner-of-war camps.

Excellent relationships have been maintained with both the Army and Navy camps and on a number of occasions it has been possible for the State Director to give considerable aid to the Army and Navy personnel in planning their control programs.



Boat for Dusting Water Chestnuts



Casting Ditch Lining

Installing Ditch Lining

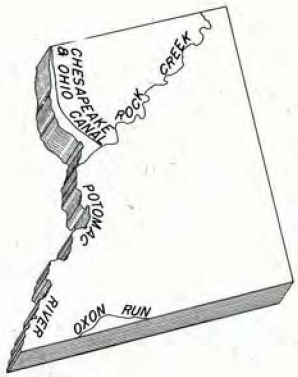
DISTRICT OF COLUMBIA

The fiscal year just ended has witnessed the elimination of most of the important breeding places of *Anopheles quadrimaculatus* in the District of Columbia.

The water chestnut in Oxon Run, which supported abundant "*quad*" production, has been eliminated by cutting and by manual removal of the plants. The Chesapeake and Ohio Canal, which became a "*quad*" breeding place when it fell into disuse of a result of destruction of inlet works by a Potomac River flood, was restored for pleasure boating and no longer presents a control problem. Numerous smaller breeding places have been eliminated by drainage and filling.

The principal remaining breeding places are ornamental pools and ponds which vary in size from less than 50 square feet to as much as an acre. There are over 1000 of these in the District and a small percentage of them breed *Anopheles quadrimaculatus*.

Although malaria has not been an important disease in the District of Columbia since the early part of this century, the world importance of the area at this time and the presence of large numbers of malaria carriers among the population requires that greater care than usual be taken to prevent malaria transmission. A thorough entomological inspection program covering the entire 69 square miles of the District of Columbia has been maintained, and the density of *Anopheles quadrimaculatus* has been held to a very low level.



HEALTH OFFICER
GEORGE C. RUHLAND

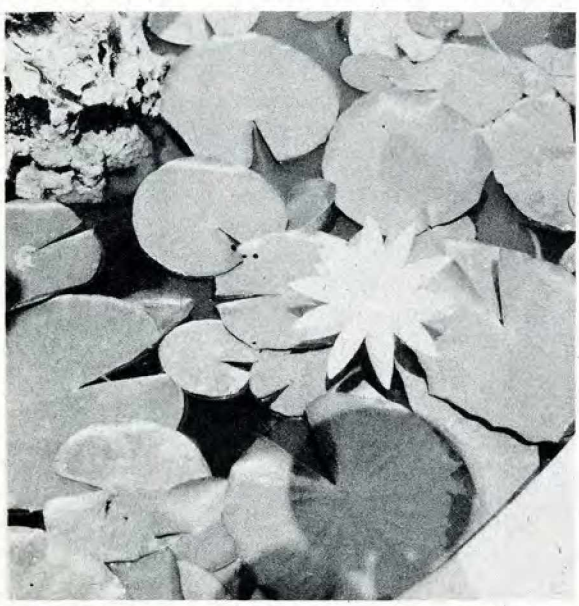
BUREAU OF SANITATION

DISTRICT OF COLUMBIA
M.C.W.A. OFFICE

I WAR AREA
21 WAR ESTABLISHMENTS PROTECTED

In January 1944 the MCWA program was transferred from the Bureau of Communicable Diseases to the Bureau of Sanitation of the District of Columbia Health Department. Coordination of MCWA work with the normal functions of the latter Bureau has led to the elimination or control of some of the mosquito breeding places by private property owners through use of the police power of the Health Department over public nuisances. More extensive use of these powers will probably be made in the future and closer coordination of MCWA work with other environmental sanitation activities of the Health Department effected.

Plans are being made to train inspectors of the Bureau of Sanitation in the technique of mosquito control in order that they may report more intelligently on mosquito nuisances discovered incidental to other work. This will enable Health Department personnel to continue anti-malaria and anti-mosquito work after the war.



"Quad" Breeding Place in a Lily Pond

PUERTO RICO
JAMAICA

16 WAR AREAS

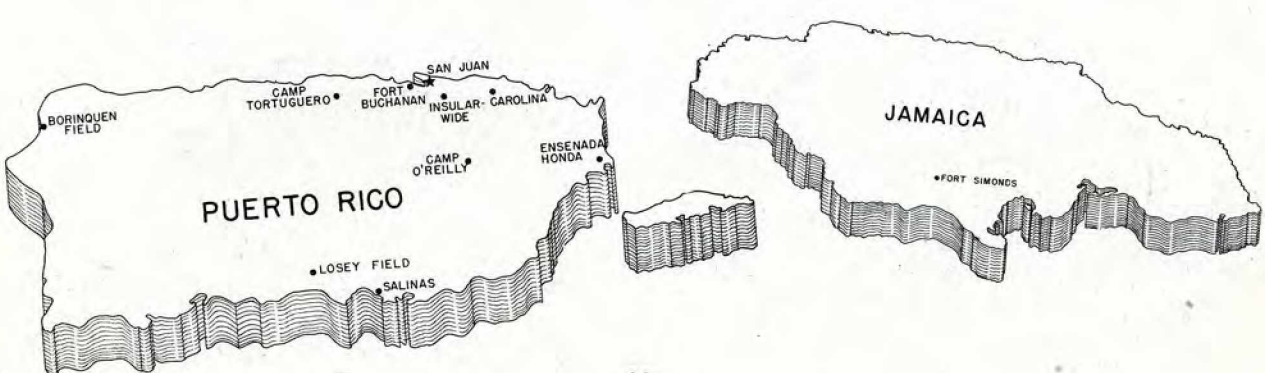
29 WAR ESTABLISHMENTS PROTECTED

Animal Bait Trap for Sampling Mosquitoes

MCWA performs two functions in the Caribbean Theater of Operations. Its major activity is the prosecution of malaria control operations at Army and Navy bases in Puerto Rico and Jamaica. It is also concerned with a larger area comprising all Army posts in the West Indies and British, French, and Dutch Guiana on the northern coast of South America.

The officer in charge of MCWA operations in Puerto Rico and Jamaica is a member of an Army Malaria Board which exercises general technical supervision over Army malaria control planning, practices, and financial allotments in the general area described above. In this assignment he is assisted by the other MCWA officers, who participate in detailed malaria investigations for the Board. Control work is directed against the larvae of *Anopheles albimanus* and is concentrated largely in extra-reservation breeding places within mosquito flight range of military populations.

MCWA activities in Puerto Rico and Jamaica are characterized by the following features which distinguish them from operations at other locations. (1) The objective has been the reduction of existing malaria among military forces rather than the suppression of a malaria hazard. Malaria incidence provides a sensitive yardstick in planning and prosecuting malaria control operations. Work undertaken has been rigidly selected and systematically operated, and its effectiveness in terms of malaria reduction has been adequately demonstrated. (2) Lines of administration have been simplified because of the military urgency of the problem. (3) The malaria mosquito vector involved, *Anopheles albimanus*, breeds in a great variety of aquatic situations and has a long flight

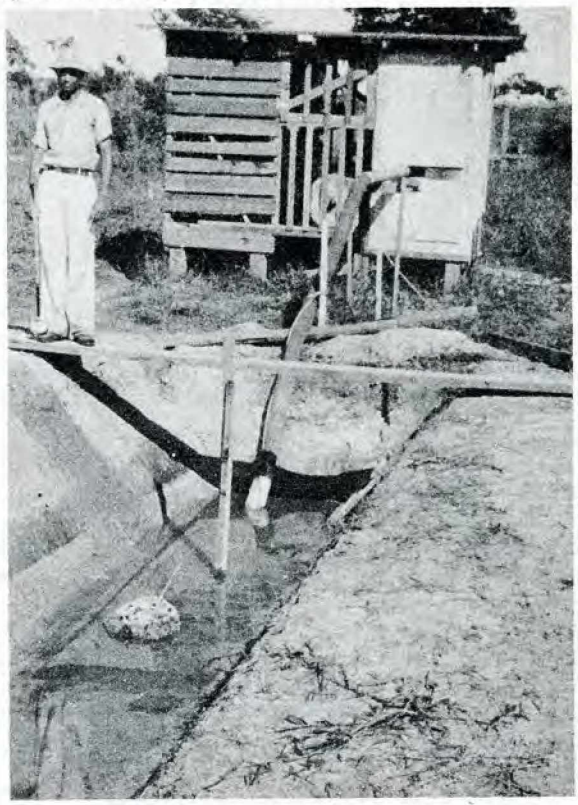


Dipping for *albimanus* Larvae

range. These factors have necessitated intensification of control effort and extension of the control area to four times the size customary in continental United States. (4) Supply and procurement have been particularly important elements of program operation. The slow arrival of shipments from the United States and the difficulty of securing services, supplies, materials, and equipment locally to meet unexpected exigencies, have necessitated planning activities and requirements far in advance and have resulted in lengthy delays and stoppages when equipment breakdowns have occurred.

Larviciding Crew at Work

At the beginning of the fiscal year 1944, *albimanus* mosquitoes in 4 main war areas were being controlled satisfactorily by concentrated larvicidal and minor drainage activities. It was anticipated that this level of *albimanus* production could not be maintained by larviciding alone during and following the heavier rains in the fall. Consequently, effort was directed towards the completion of major drainage projects in these areas. The work was not sufficiently complete at the onset of the rainy season in the fall of 1943 to prevent some increase in *albimanus* production, but mosquito collections rose above arbitrarily safe limits in only two posts, and malaria increased at only one post.



Portable Pump

During the year, larvicidal and minor drainage projects have been operated in five principal war areas, and major drainage projects in four areas; inspection programs have been carried on in two Army areas and in one Navy installation. MCWA has also operated a concrete products

Concrete Products Plant

plant and storage warehouse project, and a Service officer has supervised the operation of an Army concrete products plant.

LARVICIDING AND MINOR DRAINAGE

The larvicidal program, which has been the major activity, has functioned almost continuously in five areas. Activities have consisted mainly of applying paris green with hand and power equipment at weekly intervals.

Emphasis has been placed on providing closer supervision to field operations and applying control measures in accordance with entomological interpretation of breeding conditions. This policy, together with effects of relatively dry weather from January to May 1944, has made possible a reduction in larviciding and minor drainage personnel from a maximum of 478 in November, 1943 to 329 in May, 1944. A further reduction is expected in two or three of the main control areas.

A portable pump was used to dry up shallow ponds which formed in "chaca" sinks after heavy rains. This method was used because the ponds are surrounded by higher ground and cannot be drained by ordinary ditching.

In general, minor drainage has been carried on with personnel assigned to the larvicidal projects. Cleaning and clearing, an important activity on the island, has been performed with larviciding crews after dusting operations have been completed. The most important problem associated with larviciding in Puerto Rico, as compared to general war areas in the States, is extensive cultivated or abandoned sugar-cane lands, pasture lands with seepage areas fed by sugar-cane irrigation systems, and brackish mangrove and cattail swamps.

Constructing Large Drainage Ditch

Losey Field Pumping Station

MAJOR DRAINAGE

Major drainage of a permanent nature has been prosecuted in the intra-reservation areas of all military posts of malaria importance by the U. S. Engineers and by MCWA in adjoining extra-reservation areas where experience and entomological data indicated that satisfactory control could not be achieved with larvicidal measures alone. The most important proj-

ect involved ditches at or below sea level, making pumping necessary. A pumping station was constructed under the direct supervision of MCWA and financed jointly by the Public Health Service, Insular Health Dept., and FWA. This dewaters an area of approximately 500 acres. Another MCWA sponsored and operated project consists of two drainage systems. One was designed primarily to lower the elevation of Lake Tortuguero by a canal into the sea, and the other is a canal system designed to drain a marsh of approximately 1,000 acres. Both systems, which were completed about the end of 1943, have been beneficial to successful larvicidal operations during the present calendar year and should ensure the maintenance of low mosquito populations during the approaching wet season.

Installing Highway Cross Drain

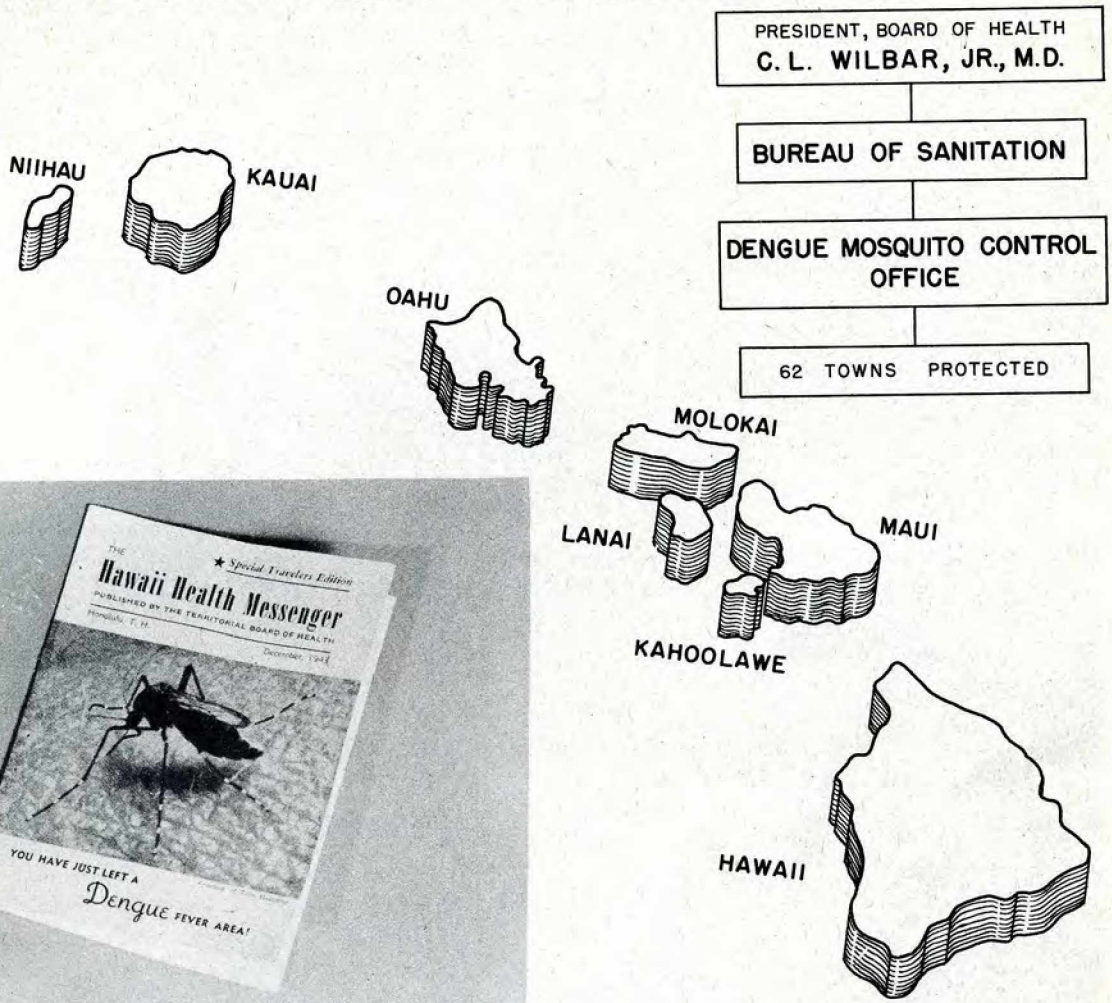
Canal Draining into the Sea

Puerto Rican Village that was Moved

One major drainage project operated by MCWA and the U. S. Engineers in the vicinity of Ft. Buchanan has been completed recently. This work was necessary largely as a result of a hydraulic fill made by the U. S. Engineers in a drainage basin. The completed work consists of a pumping station equipped with two 30,000 gallon per minute low lift pumps. The main canal is approximately 12,500 feet long and 50 feet wide and has a system of open, lined tributary ditches. An initial phase of this project consisted of moving Santa Ana --a small village of 66 houses. This village was located in a direct line between a large swamp and the western inhabited area of Ft. Buchanan. A blood film survey made by the Antilles Dept. Laboratory and the Insular Health Dept. showed that a large percentage of inhabitants had malaria at the time. The Army purchased land and moved the village to a location more remote from the base.

In Puerto Rico the MCWA program was operated more as an auxiliary service of the Army and Navy than as a civilian service. All Army malaria control projects were approved by a Malaria Board composed of an officer of the U. S. Army Medical Corps, a U. S. Engineer Officer, and the Officer in Charge of MCWA operations; and MCWA projects were initiated or terminated with the full knowledge of the Malaria Board. Consequently, malaria control activities of the Army and Public Health Service were very closely integrated.

HAWAIIAN ISLANDS



Dengue Warning to Inter-island Travellers

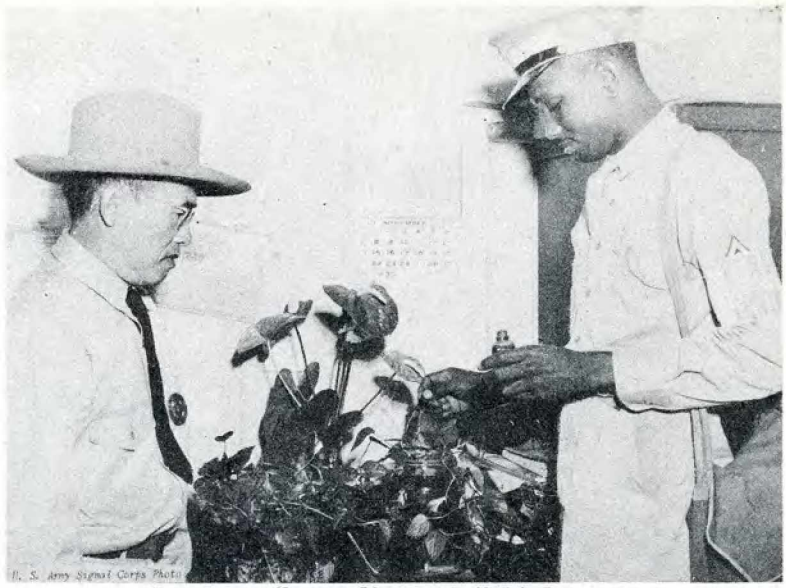
The Hawaiian Islands are isolated by two thousand miles of ocean from the nearest malaria mosquitoes. Although well within the tropics, Hawaii was entirely free of mosquitoes until about one hundred years ago. Since that time three species have successfully invaded the Territory. *Culex quinquefasciatus* Say was the first to arrive and is looked upon with suspicion because of its ability to transmit filariasis. It is the domestic, foul water, night-biting and singing mosquito and is being partially controlled incidental to the dengue control program.

Aedes aegypti (Linn.) and *Aedes albopictus* (Skuse), the dengue vectors, were introduced at a later date. These are the day-biting mosquitoes, *aegypti* being largely confined to cities while *albopictus* is actually the predominant urban species and extends over the lowland forests of all the islands.

Mosquito control was carried on in Honolulu in 1903 and 1912 and has been in operation continuously in recent years. The Rat and Mosquito Control Squad of the Chamber of Commerce was on the job at the time of the present outbreak of dengue and provided a nucleus of trained men for the emergency program. The Public Health Committee of the Chamber of Commerce was able to assist the Board of Health in this work

because of funds accumulated through a voluntary tonnage levy on all shipments passing through the port of Honolulu.

Dengue has been reduced almost to the vanishing point during the past year. Future efforts will be directed at complete elimination of dengue transmission and at control of mosquito breeding, to decrease the hazards of a new epidemic in case new carriers arrive in the Territory. Quarantine measures will continue to be the first line of defense against introduction of malaria vectors.



Treating House Plant to Kill Larvae

Draining Water from Pineapple Lilies

Dusting Junk Pile